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ABSTRACT

This report is one in a series written on the Resource Requirements Prediction Model (RRPM-1) developed by the National Center for Higher Education Management Systems (NCHEMS). This particular document is a guide to the project manager, the person responsible for marshaling and coordinating the resources necessary to implement RRPM-1. The Guide has 2 main functions: (1) to provide some details on the type and amount of resources required; and (2) to identify some of the problems of implementation and some approaches to their solution. Hopefully, the reading of this Guide will make future implementations of RRPM-1 more economical and easier to accomplish than otherwise would be the case. (HS)

ED 062 950

A RESOURCE REQUIREMENTS PREDICTION MODEL (RRPM-1): GUIDE FOR THE PROJECT MANAGER

Technical Report 20

A RESOURCE REQUIREMENTS PREDICTION MODEL (RRPM-1):
GUIDE FOR THE PROJECT MANAGER
TECHNICAL REPORT 20

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National
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National Center for Higher Education Management Systems at WICHE

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To design, develop, and encourage the implementation of management information systems and data bases including common data elements in institutions and agencies of higher education that will:

- provide improved information to higher education administration at all levels.
- facilitate exchange of comparable data among institutions.
- facilitate reporting of comparable information at the state and national levels.

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NATIONAL CENTER FOR HIGHER EDUCATION

MANAGEMENT SYSTEMS AT WICHE

A RESOURCE REQUIREMEMTS PREDICTION MODEL (RRPM-1) --GUIDE FOR THE PROJECT MANAGER

Technical Report 20

by

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Systems at WICHE

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80302

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TABLE OF CONTENTS

Chapter Page

Preface v

Acknowledgements. ix

List of Figures xi

1. Introduction 1

2. The Overview of Implementation 2

3. Organization & Planning for the Project. 4

    3.1 Equipment Required. 4

    3.2 Personnel Required. 4

    3.3 Time Required 5

    3.4 Implementation Strategies 6

4. The Model: Its Structure & Modification 8

    4.1 Structure of Model. 8

    4.2 Modifications of Model. 8

        4.2.1 Cost Functions for Support Costs. 16

        4.2.2 Dimensions. 17

        4.2.3 Assumptions in Computations 19

        4.2.4 Other Institutional Models. 19

5. Data Generation. 20

    5.1 Introduction. 20

    5.2 Data to Collect 20

        5.2.1 Data Sources. 21

        5.2.2 Data Elements 21

            5.2.2.1 The Induced Course Load Matrix. 21

TABLE OF CONTENTS (continued)

Chapter Page

5.2.2.1.1 The Concept of ICLM. 23

5.2.2.1.2 ICLM Representations 23

5.2.2.1.3 Generations of the ICLM. . . 26

5.2.2.1.4 Some Reservations and Problems Concerning the ICLM 27

5.2.3 Estimation Coefficients. 28

5.2.4 Independent Variables. 29

5.3 Pre-Processor. 31

5.3.1 PPP1 31

5.3.2 PPP2 33

5.3.3 PPP3 36

5.4 Control Totals 36

5.5 Correcting Errors. 38

6. Validation Strategies 41

6.1 Introduction 41

6.2 Validation Strategies. 41

6.3 Considerations of Experimental Design. 44

6.3.1 Level of Aggregation for Testing 44

6.3.2 Sample Size. 44

6.3.3 Quanity of Data. 44

6.3.4 Standards of Testing 45

TABLE OF CONTENTS (continued)

Chapter Page

6.4 Phases of Testing. 45

6.5 Detecting Problems 48

6.5.1 Intermediate Output. 48

6.5.2 TRACER-TRAINER 49

7. Using the Model 73

7.1 Running the Model. 73

7.2 Output Generation. 73

7.3 RRPM-1 in Planning Cycle 59

7.4 Cautions Concerning Output 61

8. Orientation and Training. 63

8.1 Introduction 63

8.2 The Audience 63

8.3 Content. 64

8.4 Strategies of Presentation 64

8.4.1 Lectures, Seminars, and Discussion Groups. 64

8.4.2 Games. 65

8.4.3 TRACER-TRAINER 65

8.4.4 Publications 66

8.5 Sequence and Schedule. 66

9. Summary & Conclusions 68

Appendix: Sample Calculations 70

Selected Annotated Bibliography. 93

References 109

PREFACE

RRPM-1 Documentation

This publication is part of the documentation for the initial NCHEMS Resource Requirements Prediction Model, RRPM-1. The total documentation package consist of a number of publications, a set of computer programs, and a set of visuals to support training. These materials are available individually or in sets. Three sets of documentation have been developed for various purposes.

A. One set of documents is addressed to administrators and/or managers of higher education institutions. It consists of three documents that describe the structure of the model and its use in an institution of higher education:

NCHEMS Technical Report 19, A Resource Requirements Prediction Model (RRPM-1): An Introduction to the Model

NCHEMS Technical Report 20, A Resource Requirements Prediction Model (RRPM-1): Guide for the Project Manager

NCHEMS Technical Report 21, A Resource Requirements Prediction Model (RRPM-1): Report on the Pilot Studies

The Introduction is addressed to higher education administrators, specifically the top administrator who must make a decision whether or not to implement RRPM It traces briefly the development of RRPM, its design objectives, testing and implementation at pilot institutions, and the resources required for implementation. It also lists some evaluations by the pilot institutions. The Introduction is based in part on the initial description of the model published in January 1971, The Resource Requirements Prediction Model 1 (RRPM-1): An Overview. The material in this document is now contained in the Introductio and in the Guide. The Guide provides information on the structure of the model and the data required by the model to simulate the institution. In addition, the Guide discusses the process of implementation with special attention to modifying the model, testing it, and training personnel in understanding and using the model. Also included in the Guide is an extensive annotated bibliography of literature related to planning in higher education.

B. The second set of documentation is technical information of interest to the systems analyst and the programmer. This documentation set consists of:

NCHEMS Technical Report 22, A Resource Requirements Prediction Model (RRPM-1): Programmer's Manual

NCHEMS Technical Report 23, A Resource Requirements Prediction Model (RRPM-1): Input Specifications

RRPM-1 Input-Output Package

Computer Programs for RRPM System

The Programmer's Manual discusses the details of the RRPM-1 computer programs. It also contains an algebraic representation of RRPM-1 that will be useful in understanding the analytical details of the model. The inputs required for RRPM are described in the Input Specifications. Included are blank input forms for manual data input. Samples of input forms completed for a hypothetical institution and the output reports generated from the sample input data are contained in the Input-Output package. This will facilitate the testing of the programs using the test data set provided on tape.

C. The third set in the documentation package for RRPM-1 contains materials to aid in training on the model. At the present time this package contains:

Resource Requirements Prediction Model (RRPM-1) Technical Workshop Notes

RRPM-1 Visual Aids

The Notes are hard copy reproductions of the visual aids used at the RRPM-1 Technical Workshop conducted by NCHEMS. The RRPM-1 Visual Aids are duplicates of the visuals used in the RRPM-1 Technical Workshop. These materials are made available to encourage institutions to undertake training of their personnel in the use of the model. Additional materials may be added at a later date.

The RRPM system was developed under a USOE Contract No. OEC-0-8-980708-4533(010). The development cost was supplemented in part by the pilot institutions that gave much of their time and resources to testing and implementing the model. The results of this cooperative effort are available to all interested parties at a nominal cost to cover reproduction and distribution. Further details regarding the RRPM project can be obtained by writing to:

Mr. James S. Martin
RRPM Project Manager
National Center for Higher Education
Management Systems at WICHE
P. O. Drawer P
Boulder, Colorado 80302

The following table attempts to aid the reader by identifying the relevant areas of the documentation package. The table is based on different levels of interest in the materials relative to the reader's role in implementating and using the RRPM-1 system. The coding in the table refers to the chapter or section in the Technical Reports; e.g. TR 19-5 refers to NCHEMS Technical Report 19, A Resource Requirements Prediction (RRPM-1): An Introduction to the Model, Section 5.

	ADMINISTRATOR/ EXECUTIVE USER	PROJECT MANAGER	ANALYST/ PROGRAMMER
IMPLEMENTATION	TR19-7	TR19-7 TR20-2,8	TR22-5
MODEL USES	TR19-5	TR20-7	TR22-3
PILOT TEST	TR19-4,6 TR21	TR19-4 TR21	TR21
STRUCTURE	TR19-5 TR20-4	TR20-4 TR22-2	TR20-4 TR22-2
OUTPUTS	TR19-A,B	TR19-A,B TR20-7 TR22-4	TR22-4
INPUTS	--------	TR20-5 TR23	TR22-1 TR23
HARDWARE	--------	TR20-3 TR21-1 TR22-2,4	TR22-2,4,5

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This document originated in RRPM Task Force Meetings. The Task Force members outlined the contents and spent much of their time checking the contents and suggesting improvements. Additional contributions were made by Dr. D. L. Trautman who prepared the structure for Chapter 4; Dr. Frank Jewett, who rewrote Section 5.2.2.1; and Mr. Cohn who helped with most of Section 7.3.

Special thanks are also due Dr. Warren Gulko and Mr. Jim Martin of the NCHEMS staff because they contributed freely and substantially throughout the preparation of this document.

LIST OF FIGURES

Page

Figure 2.1: Overall Network Diagram of the Implementation of RRPM 1.3 3

Figure 3.1: Type of Personnel Skills Required in Different Activities 4

Figure 3.2: One Possible GANTT Chart for Implementing RRPM-1 . . . 7

Figure 4.1: Logic Flow of RRPM 1.3 9

Figure 4.2: Dimensions of RRPM 1.3 13

Figure 4.3: Organization of NCHEMS' Program Classification Structure 14

Figure 4.4: The Scope of RRPM 1.3 in the Program Classification Structure. 15

Figure 4.5: General Form of Support Cost Calculation 16

Figure 4.6: Comparison of Dimensions for RRPMs' 1.3, 1.4, and 1.5. 18

Figure 5.1: Data for RRPM 1.3 From Institutional Files 22

Figure 5.2: Student Credit Hours by Department & Major 23

Figure 5.3: ICLM, Alternative 1, Student Credit Hours Taken By the Typical Student of Each Major in Different Departments. 24

Figure 5.4: Illustration of Departmental Load Calculation Using ICLM Alternative 1 24

Figure 5.5: ICLM, Alternative 2, Distribution of Major SCH Among Departments. 25

Figure 5.6: Illustration of Departmental Load Calculation Using ICLM Alternative 2 25

Figure 5.7: Dimensions of the ICLM 26

Figure 5.8: Summary of Institutional Inputs and Their Dimensions . 30

LIST OF FIGURES (continued)

Page

Figure 5.9: The Roles and Interrelationships of the Partial Pre-Processors 32

Figure 5.10: Samples of Partial Pre-Processor 1 34

Figure 5.11: Samples of Partial Pre-Processor 2 37

Figure 5.12: Checking Totals for Consistency. 39

Figure 5.13: Examples of Control Totals of Headcount and SCH. . . . 40

Figure 6.1: Process of Validation. 42

Figure 6.2: Iternations in Validation with Historical (accounting) Data 42

Figure 6.3: Comparison of Predicted and Actual Values (instructional program). 46

Figure 6.4: Comparison of Predicted and Actual Values (non-instructional programs) 47

Figure 6.5: Phases of Testing. 48

Figure 6.6: Samples of Intermediate Output 50

Figure 6.7: Samples of Parts of the TRAINER-TRACER Output. 51

Figure 7.1: RRPM 1.3 System for Reporting. 54

Figure 7.2: Levels of Aggregation of Standard Output from RRPM-1 . 55

Figure 7.3: Sample of Report Code and Its Meaning. 56

Figure 7.4: RRPM 1.3 Report Code 57

Figure 7.5: Report Code: Its Structure, Levels of Aggregation References to Sample Reports 58

Figure 7.6: Summary of Output Types for RRPM-1 60

Figure 7.7: RRPM in Planning Cycle 62

Figure 8.1 Orientation and Training Table 66

CHAPTER ONE

INTRODUCTION

This report is one in a series written on the Resource Requirements Prediction Model (RRPM-1) developed by the National Center for Higher Education Management Systems (NCHEMS). The first document of the series is an introduction[1] addressed primarily to top management. That document discusses the nature and structure of RRPM-1, points out its capabilities and limitations, and identifies the overall resources needed for its implementation. Technical information on the inputs and programs can be found in the Programmer's Manual[2] and the Input Specifications.[3] Between the top management and the programmer is a project manager. He must marshal and coordinate the resources necessary to implement RRPM-1. It is to such a person that this Guide is addressed.

The Guide has two main functions: one is to provide some details on the type and amount of resources required. (Resources are time, manpower, equipment, and data). Such information adjusted for the institutional environment may be required by top management before making a decision on implementation. If the decision is made to implement, then this document has another function: it will identify some of the problems of implementation and some approaches to their solution. Hopefully, the reading of this Guide will make future implementations of RRPM-1 more economical and easier to accomplish than otherwise would be the case.

This Guide is based largely on the experience of eight institutions that pilot tested RRPM-1.2 (Version 2). From their experiences RRPM-1.3 (Version 3) was developed and released. An overall analysis of the pilot test is discussed in a report on the pilot studies of RRPM-1,[4] a document that is highly recommended as collateral reading.

There are no mathematical prerequisites for the reading of this Guide. What is required is an acquaintance with electronic data processing, a knowledge of modeling,[5] and some experience with systems projects.[6] The reader is expected to be able to read flowcharts and block diagrams, which are used extensively in the pages that follow. They are designed to be self-explanatory and hence will not be explained in detail. Network diagrams are also used, but these will be explained.

CHAPTER TWO

THE OVERVIEW OF IMPLEMENTATION

The main activities in the implementation of RRPM-1 are shown in a network diagram in Figure 2.1. (See page 3).

The implementation as discussed in the Guide and as depicted in Figure 2.1 assumes the availability of RRPM-1.3 from NCHEMS (activity 5-10). Availability is followed by organizing and planning for implementation (activity 10-100). Then a set of parallel activities must occur: data generation (activity 100-200), model modifications (if any) (activity 100-400), and initial orientation and training (100-500). The dashed arrows are dummy activities. These are followed by another set of parallel activities: documentation (400-450) and the test of the vaildity of the model[1] using institutional data (activity 400-500). If the test is considered successful, then the initial implementation of RRPM-1.3 is complete, and it can thereafter be employed as a tool of institutional planning and decision making (activity 500-800). Parallel to such use, the model must be maintained and updated to reflect changing environmental conditions and management needs (activity 500-600). Also parallel, there should be a continuation of the orientation training program (activity 500-700) and the development of related sub-models (activity 500-650) to reflect unique institutional needs. (Examples would include Revenue Forcasting and Facilities Planning.) These activities are continuous and are terminated only if RRPM-1.3 is replaced by a more sophisticated and more useful model.

Each of the activities mentioned above and shown in Figure 2.1 will be discussed in some detail in sections to follow. The first of these activities is organization and planning for implementation. This is the topic of the next chapter.

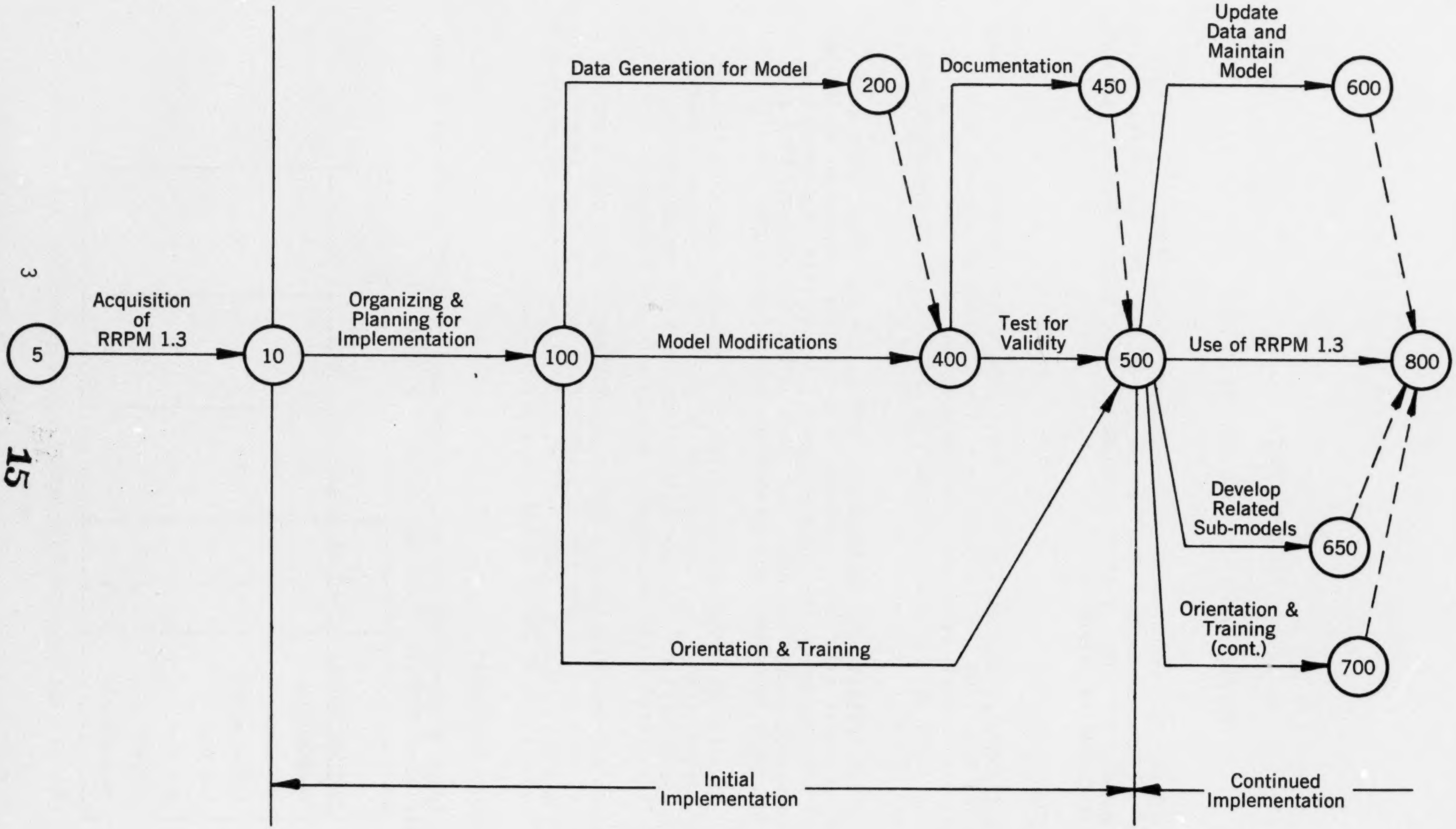


Figure 2.1: Overall Network Diagram of the Implementation of RRPM-1.3

CHAPTER THREE

ORGANIZATION & PLANNING FOR THE PROJECT

An important part of organizing for the implementation of RRPM-1 is the collection of necessary resources required for the project, mainly, being: equipment, personnel, and time. Each is discussed in turn below. Another resource, data, is discussed in Chapter 5.

3.1 Equipment Required

The smallest computer used by the pilot institutions implementing RRPM-1.2 was an IBM 360/40 requiring 180K core memory.[1] The training version of RRPM-1.3 (RRPM-1.35) with greatly reduced dimensions uses less than 100K.[2] The pilot institutions using IBM equipment used both OS and DOS. Other computers used were CDC and UNIVAC.

For three pilot institutions implementing RRPM-1, the equipment needs were larger than what was available on campus.[3] In two cases, equipment at another educational institution in the state was used. In one case, equipment at a central processing center was used. In those cases, the response time and coordinating costs increased, but performance was not affected.

In one institution the output was generated on a terminal operating through remote batch entry (CRBE), but all changes to the files were done in batch at the processing center.[4] In two institutions, much of the processing, including file creation and maintenance, was done on the terminal.[5]

Two compilers are required for the RRPM-1.3. FORTRAN IV with direct access capability is required for the RRPM-1 program that does the basic computations and also for the TRACER-TRAINER. COBOL E (i.e., almost any version) is required for the report generation of RRPM-1.3 and the pre-processor.

3.2 Personnel Required

Different types of personnel are required for most types of activities in the implementation of RRPM-1. These are shown in Figure 3.1.

SKILLS/ACTIVITIES	DATA COLLECTION	DATA VALIDATION	VALIDATE MODEL	ORIENTATION AND TRAINING
Management Team		X	X	X
Statistician/IR	X	X	X	
Systems Analyst	X	X	X	X
Programmer	X			
Data Clerk	X	X	X	
Secretary	X	X	X	X
Project Manager	X	X	X	X

Fig. 3.1. Type of Personnel Skills Required in Different Activities

Some activities (not listed in Figure 3.1) require only one type of person. For example, for programming modifications to the model and maintenance only a programmer is required. But in some activities a variety of skills, backgrounds, and experience are required. An example would be the evaluation of the model. This activity should be performed by an "analytical team" of personnel selected so as to meet the varied requirements of such a task.[6] Such an approach was taken by all pilot institutions. Some pilot institutions found the team not only very productive in evaluating the model but also an excellent means of involving personnel on campus who could profit from the use of the model. The team was also useful in determining the modifications needed to the model, the changes in output necessary for most effective use by management, the collection and checking of the input data, and also the evaluation of the model and use of its output. The team was also useful in providing a continuity between RRPM-1 and related such activities as the design of an institutional MIS (Management Information System) and the integration of academic planning with financial planning.

The effort in man-hours required for the implementation of RRPM-1 is a function of the extent to which the institution already has developed its data files, its activities in formal long-range planning, and finally, the knowledge and experience of its personnel assigned to the project. In the cases of the pilot institutions, most of them assigned personnel to the RRPM-1 project who were already engaged in planning or administrative data processing. In one institution, however, all personnel on the project were hired especially for the project. The latter case required additional effort on the part of project personnel in learning about the institution and put an extra burden on management to ensure that project personnel understood the goals, policies, and needs of the institution.

Values of the man-hour effort required for the implementation of RRPM-1 can be found in the report on the pilot studies. The reader is cautioned, however, that they are high values. By definition, a pilot institution does not have access to experiences stated in guides such as this one. Each pilot institution for the RRPM-1 also had such special projects as the development of a terminal implementation, the development of a pre-processor, etc. Finally, all pilot institutions experimented with new approaches to new problems that required many man-hours of effort and more than one institution repeated their implementation as a result of design change to RRPM-1.

3.3 Time Required

The time required for the completion of an implementation of RRPM-1 can be determined by calculating the "critical path" of a network such as the one shown in Figure 2.1. To do so, however, requires estimating the time of completion of each activity. The PERT (Program Evaluation Review Technique) approach of three time estimates can be taken since there is considerable uncertainty about the time required for each activity. A clue to the time estimates is the experience of the pilot institutions as discussed in this report.

The time estimation for completing activities is a function of the planning for implementation. For example, the strategy for model validation will affect the data generation activity. Similarly, plans for modifying the model can affect both the programming time and the time for data generation. Planning will be discussed later along with its respective activities, but it is within the context of these strategies that the project manager must estimate the time of completion for each activity. This should be done in consultation with the persons responsible for the activities and persons experienced with the RRPM-1 or similar projects.

The time estimates for each activity completion can be used to determine calendar dates for the start and completion of each activity. This can be expressed in a GANTT chart as shown in Figure 3.2. (See page 7 .) The activities shown there are merely suggestive. Each institution might have a unique set of activities relevant to its environment. A study of the pilot experiences may help to anticipate some of these.

Such a chart can be drawn manually or by a computer program that calculates the Critical Path. The activity assignments to different personnel can be identified by colors on the chart together with a date giving the project manager a tool for project control. The formal approaches of project control such as PERT or the GANTT Chart need only be used in projects that have many interrelated activities. In many implementations of RRPM-1, they will not be necessary.

The scale at the bottom of Figure 3.2 has no time unit. Each unit could be, say, one week or two weeks so that project completion would be one or two years respectively. The completion time would depend on the priority assigned to the project, the quality and dedication of personnel assigned, and the complexity of the institution.

3.4 Implementation Strategies

Part of organizing for RRPM-1 requires the selection of strategies of implementation. These are discussed in the remaining chapters in the context of the general discussion of the subject: modification of the model (Chapter 4), data generation (Chaper 5), and validation of the model (Chapter 6).

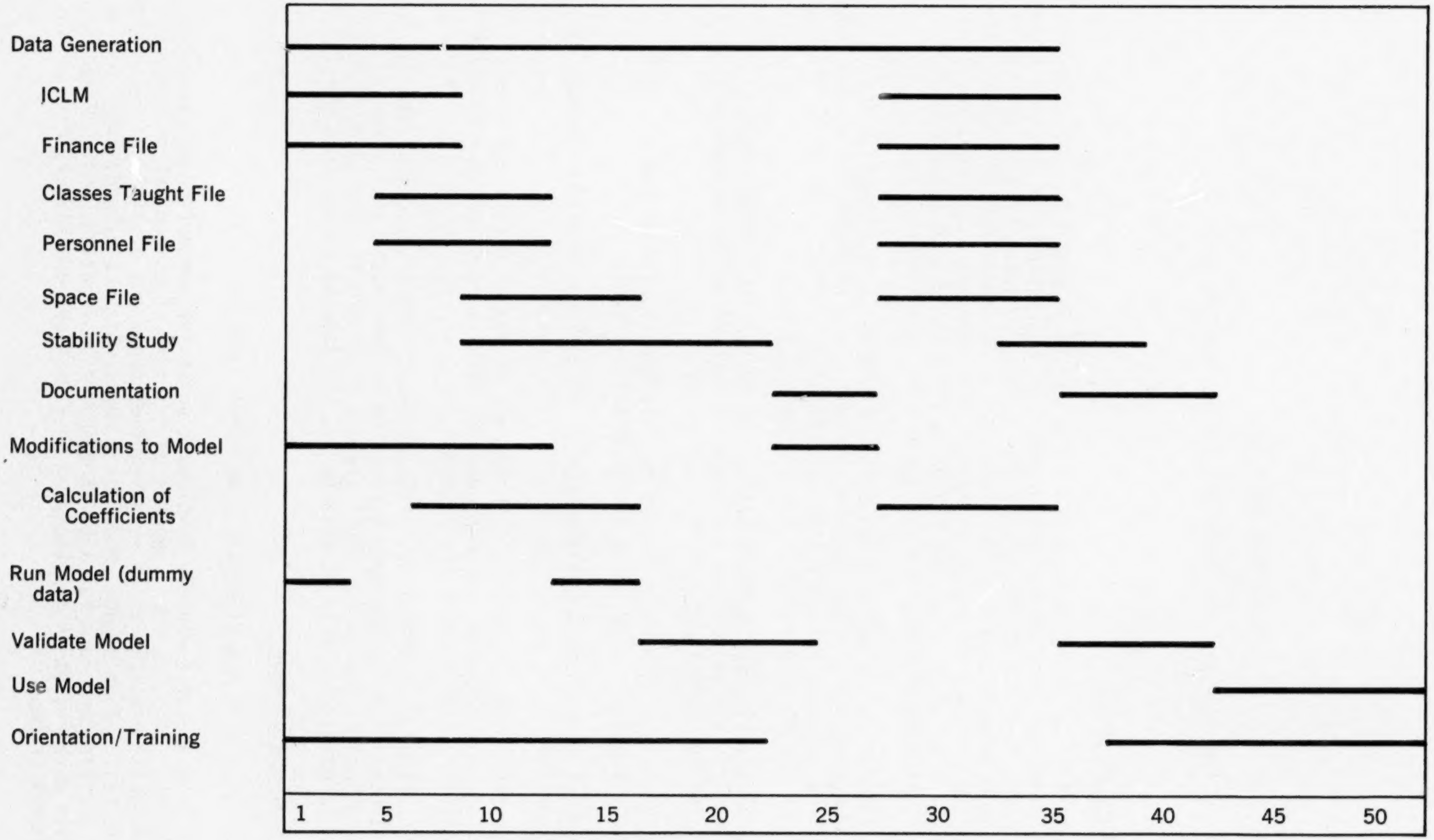


Figure 3.2: One Possible GANTT Chart for Implementing RRPM-1

CHAPTER FOUR

THE MODEL: ITS STRUCTURE & MODIFICATION

4.1 Structure of Model

The logic of RRPM-1.3 is shown in a block diagram in Figure 4.1. (See page 9 .) The maximum dimensions of the variables used for instruction are shown in Figure 4.2. (See page 13.) The dimensions of the noninstructional program are consistent with the Program Classification Structure[1] (PCS) developed by NCHEMS. The programs and subprograms (with the exception of subprogram 3.3) are identified in Figure 4.3. (See page 14.) The hierarchy of the code and the scope of RRPM-1.3 in that context are shown in Figure 4.4. (See page 15.)

Numerical examples of the basic computations of RRPM-1.3 are shown in the Appendix. The computations for any one discipline can be generated by the TRACER-TRAINER routine. A sample is discussed and displayed later. The algebraic representation of the model appears in the Programmer's Manual.[2]

Special characteristics and simplifications in RRPM-1 are implied in its representation in this volume and are stated elsewhere in the documentation of RRPM-1. For emphasis these are restated below:

1. RRPM-1 is a deterministic and descriptive simulation model. It is not stochastic, nor is it an optimization model.
2. RRPM-1 is a cost accounting model. It does not consider revenue or benefits.
3. Student flow and faculty flow are not generated within the model. Student enrollment is exogenous, and faculty is calculated by using staffing coefficients for faculty.
4. The results of RRPM-1 (as with any model) are a product of its structural relationships (assumed to be continuous and linear in most cases) and of its input values, which are in some cases crucial and yet difficult to predict (e.g., the Induced Course Load Matrix).

4.2 Modifications of Model

Models invariably need modifications. As Morris puts it:

> "Skill in modeling certainly involves a selective perception of management situations. This, in turn, depends on the sort of conceptual structures one has available with which to bring some order out of giving structure to experience. Yet we seldom encounter a model which is already available in fully satisfactory form for a given management situation, and the need for creative development or modification is almost universally experienced in management science."[4]

INSTRUCTION FLOW

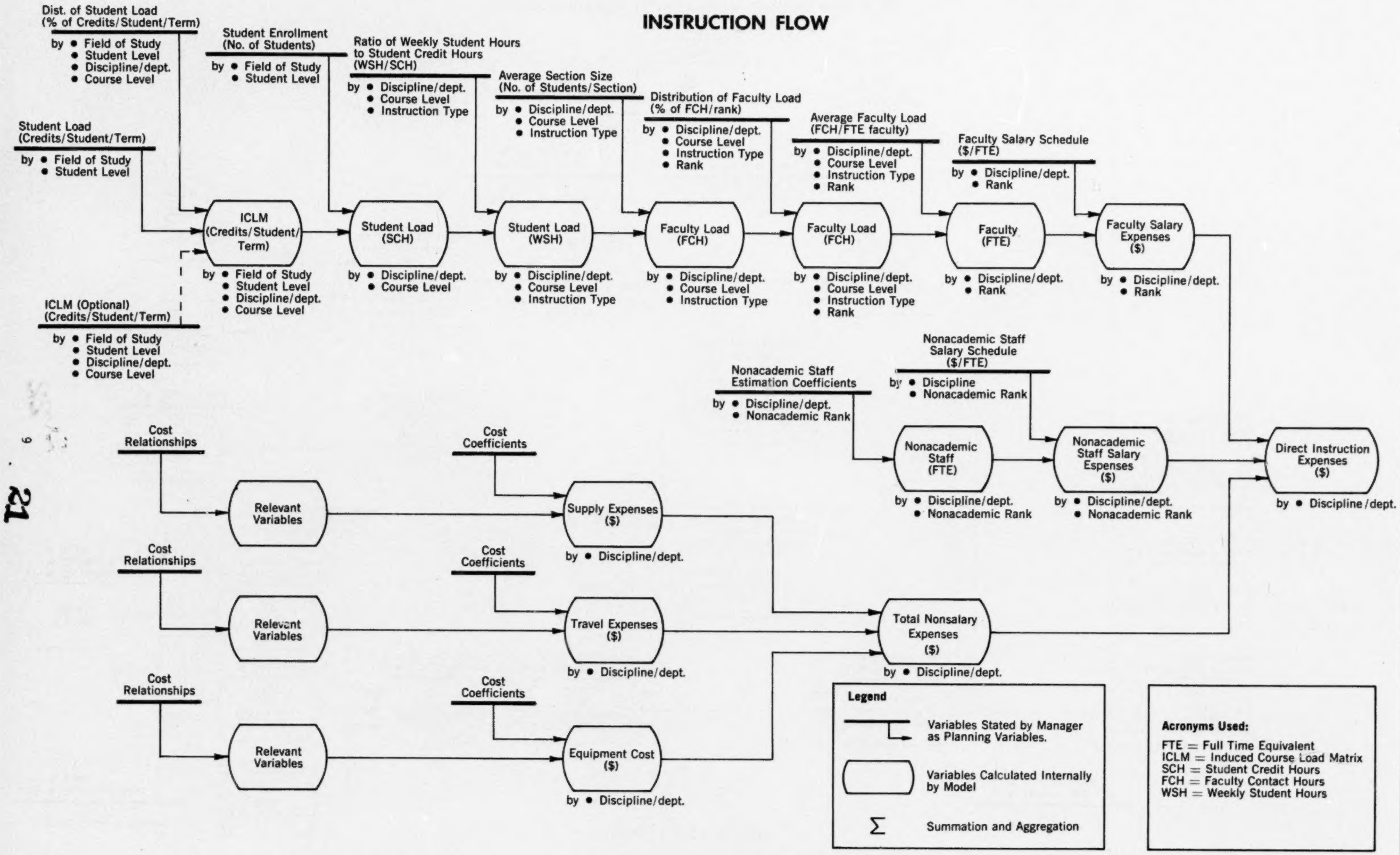

Dist. of Student Load (% of Credits/Student/Term)
by • Field of Study • Student Level • Discipline/dept. • Course Level
Student Enrollment (No. of Students)
by • Field of Study • Student Level
Ratio of Weekly Student Hours to Student Credit Hours (WSH/SCH)
by • Discipline/dept. • Course Level • Instruction Type
Average Section Size (No. of Students/Section)
by • Discipline/dept. • Course Level • Instruction Type
Distribution of Faculty Load (% of FCH/rank)
by • Discipline/dept. • Course Level • Instruction Type • Rank
Average Faculty Load (FCH/FTE faculty)
by • Discipline/dept. • Course Level • Instruction Type • Rank
Faculty Salary Schedule ($/FTE)
by • Discipline/dept. • Rank
Student Load (Credits/Student/Term)
by • Field of Study • Student Level
ICLM (Credits/Student/Term)
by • Field of Study • Student Level • Discipline/dept. • Course Level
Student Load (SCH)
by • Discipline/dept. • Course Level
Student Load (WSH)
by • Discipline/dept. • Course Level • Instruction Type
Faculty Load (FCH)
by • Discipline/dept. • Course Level • Instruction Type
Faculty Load (FCH)
by • Discipline/dept. • Course Level • Instruction Type • Rank
Faculty (FTE)
by • Discipline/dept. • Rank
Faculty Salary Expenses ($)
by • Discipline/dept. • Rank
ICLM (Optional) (Credits/Student/Term)
by • Field of Study • Student Level • Discipline/dept. • Course Level
Nonacademic Staff Salary Schedule ($/FTE)
by • Discipline • Nonacademic Rank
Nonacademic Staff Estimation Coefficients
by • Discipline/dept. • Nonacademic Rank
Nonacademic Staff (FTE)
by • Discipline/dept. • Nonacademic Rank
Nonacademic Staff Salary Espenses ($)
by • Discipline/dept. • Nonacademic Rank
Direct Instruction Expenses ($)
by • Discipline/dept.
Cost Relationships
Relevant Variables
Cost Coefficients
Supply Expenses ($)
by • Discipline/dept.
Cost Relationships
Relevant Variables
Cost Coefficients
Travel Expenses ($)
by • Discipline/dept.
Total Nonsalary Expenses ($)
by • Discipline/dept.
Cost Relationships
Relevant Variables
Cost Coefficients
Equipment Cost ($)
by • Discipline/dept.
Legend
Variables Stated by Manager as Planning Variables.
Variables Calculated Internally by Model
Σ Summation and Aggregation
Acronyms Used:
FTE = Full Time Equivalent
ICLM = Induced Course Load Matrix
SCH = Student Credit Hours
FCH = Faculty Contact Hours
WSH = Weekly Student Hours

FIGURE 4.1: LOGIC FLOW OF RRPM-1.3 (1 of 4 pages)

UNIT COST FLOW

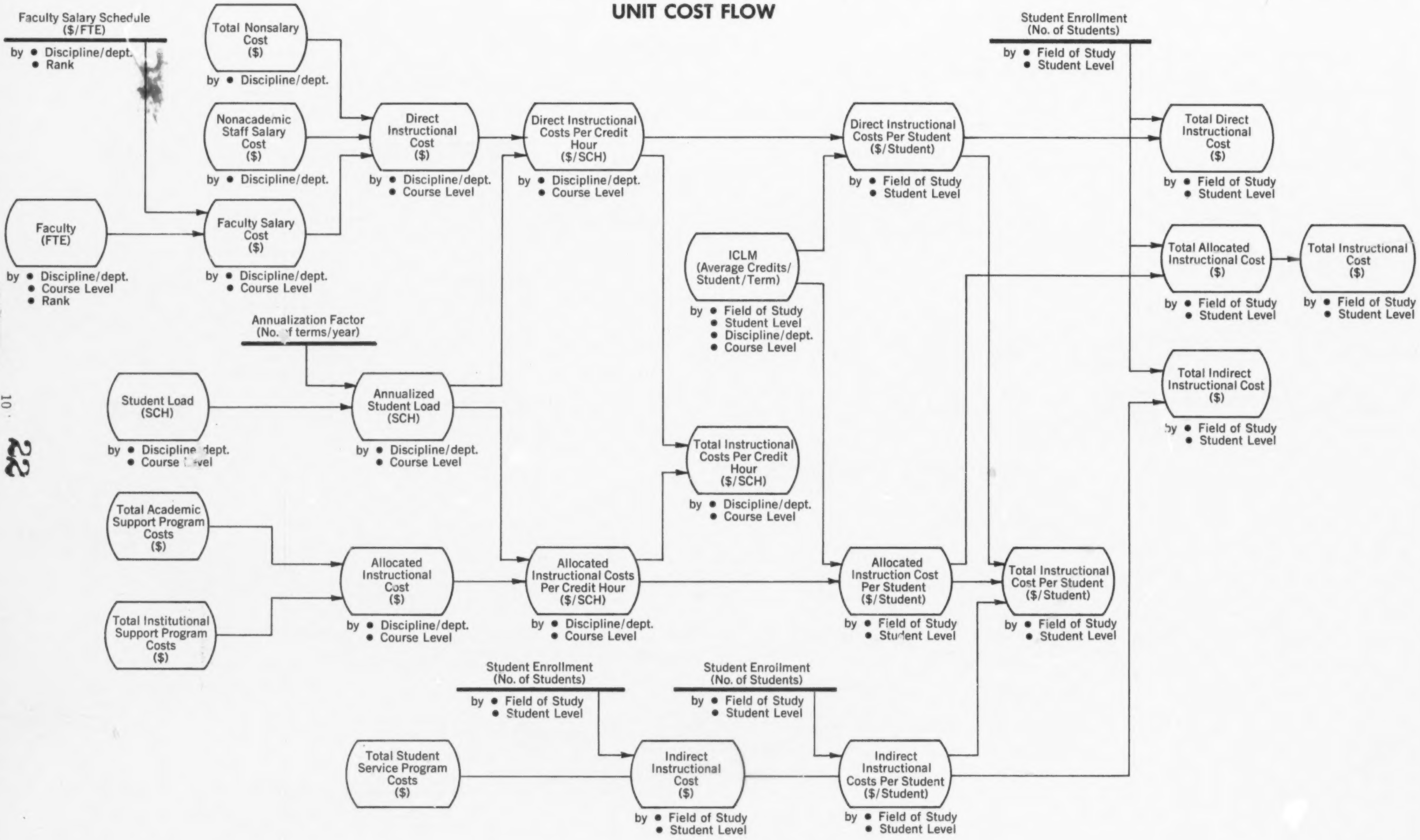

Faculty Salary Schedule ($/FTE)
by • Discipline/dept. • Rank
Total Nonsalary Cost ($)
by • Discipline/dept.
Nonacademic Staff Salary Cost ($)
by • Discipline/dept.
Faculty (FTE)
by • Discipline/dept. • Course Level • Rank
Faculty Salary Cost ($)
by • Discipline/dept. • Course Level
Direct Instructional Cost ($)
by • Discipline/dept. • Course Level
Direct Instructional Costs Per Credit Hour ($/SCH)
by • Discipline/dept. • Course Level
Annualization Factor (No. of terms/year)
Student Load (SCH)
by • Discipline/dept. • Course Level
Annualized Student Load (SCH)
by • Discipline/dept. • Course Level
Total Academic Support Program Costs ($)
Total Institutional Support Program Costs ($)
Allocated Instructional Cost ($)
by • Discipline/dept. • Course Level
Allocated Instructional Costs Per Credit Hour ($/SCH)
by • Discipline/dept. • Course Level
ICLM (Average Credits/Student/Term)
by • Field of Study • Student Level • Discipline/dept. • Course Level
Total Instructional Costs Per Credit Hour ($/SCH)
by • Discipline/dept. • Course Level
Direct Instructional Costs Per Student ($/Student)
by • Field of Study • Student Level
Allocated Instruction Cost Per Student ($/Student)
by • Field of Study • Student Level
Total Instructional Cost Per Student ($/Student)
by • Field of Study • Student Level
Student Enrollment (No. of Students)
by • Field of Study • Student Level
Total Student Service Program Costs ($)
Student Enrollment (No. of Students)
by • Field of Study • Student Level
Indirect Instructional Cost ($)
by • Field of Study • Student Level
Student Enrollment (No. of Students)
by • Field of Study • Student Level
Indirect Instructional Costs Per Student ($/Student)
by • Field of Study • Student Level
Total Direct Instructional Cost ($)
by • Field of Study • Student Level
Total Allocated Instructional Cost ($)
by • Field of Study • Student Level
Total Instructional Cost ($)
by • Field of Study • Student Level
Total Indirect Instructional Cost ($)
by • Field of Study • Student Level

FIGURE 4.1: LOGIC FLOW OF RRPM-1.3 (Continued 2 of 4)

TYPICAL NONINSTRUCTIONAL SUBPROGRAM FLOW

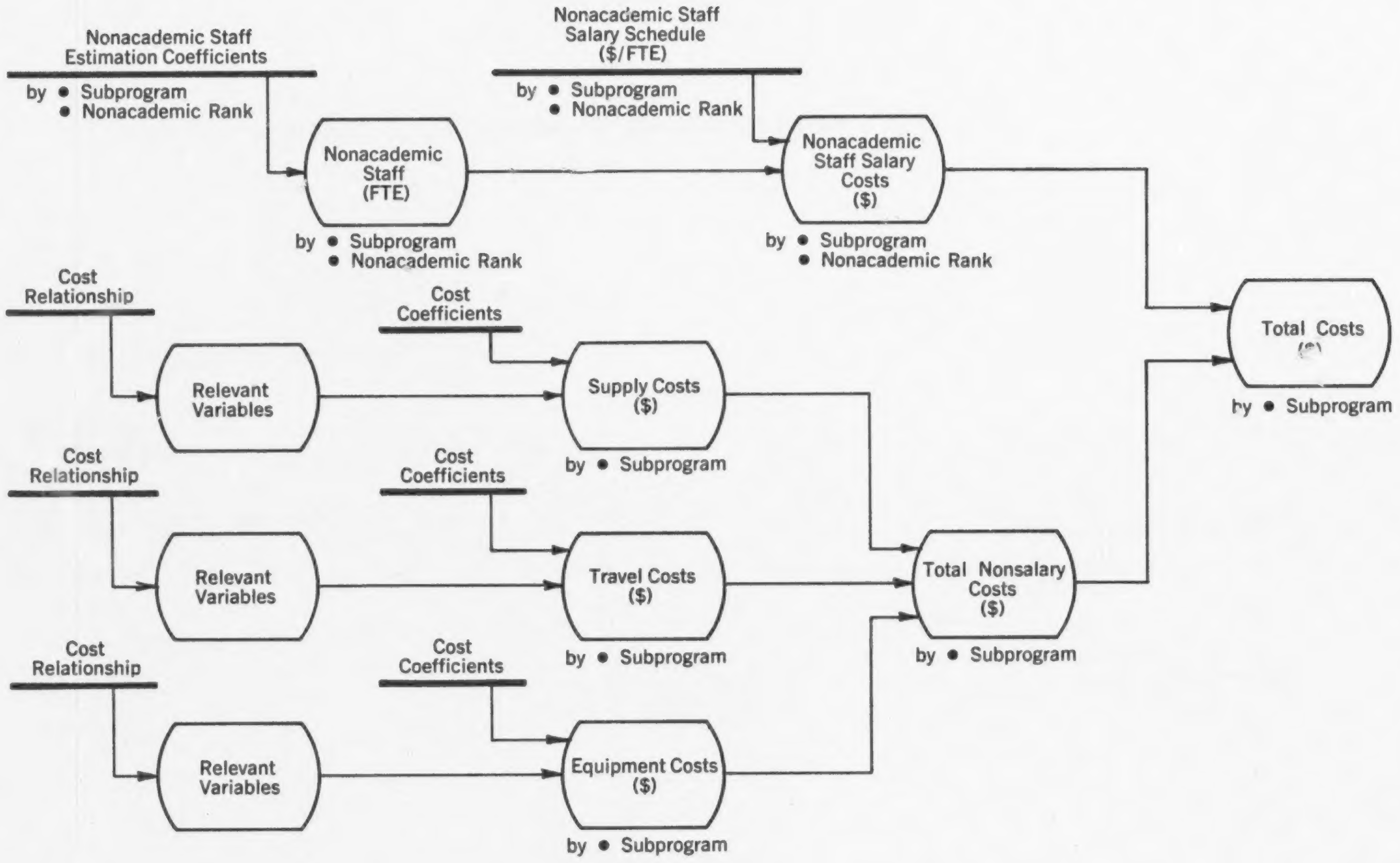


FIGURE 4.1: LOGIC FLOW OF RRPM-1.3 (Continued 3 of 4)

SPACE FLOW

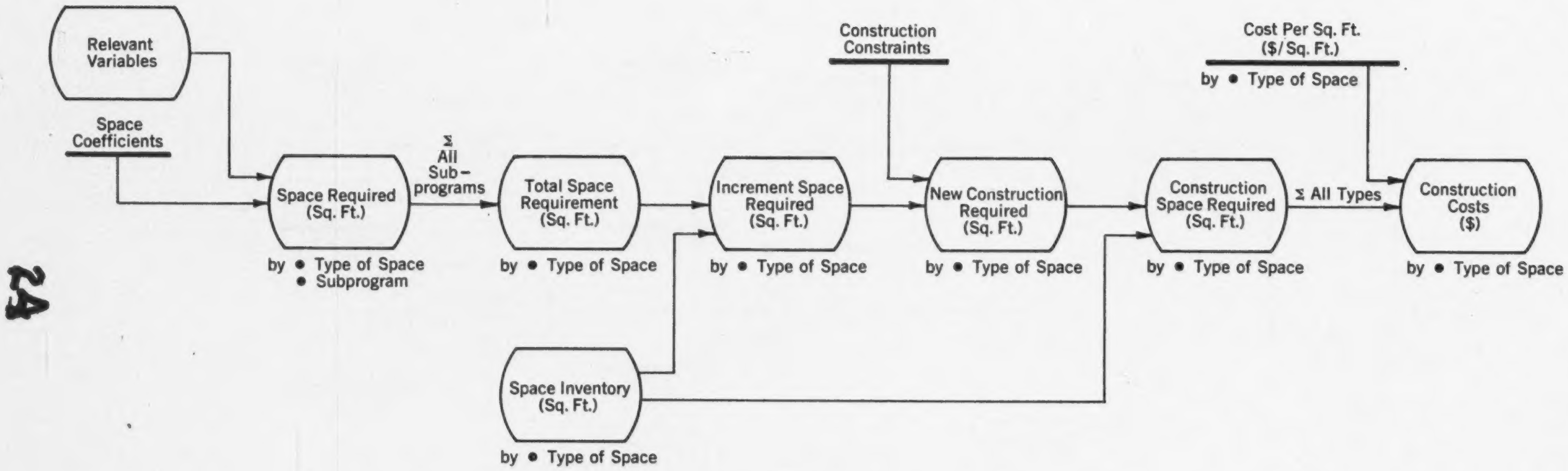


FIGURE 4.1: LOGIC FLOW OF RRPM-1.3 (Continued 4 of 4)

Major (or Fields of Study)

Any 90 majors or degrees to be defined externally.

Disciplines

Any 30 or 90 disciplines (two options allowed) at user's request

The disciplines can be aggregated into divisions, and divisions into colleges at the will of the user defined externally

Student Levels

1. Freshman
2. Sophomore
3. Junior
4. Senior & 5th Year Undergraduate
5. Graduate I (Master & First Professional Degree)
6. Graduate II (Doctoral Students)
7. Special Students

Course Levels

1. Lower Division (Preparatory)
2. Upper Division
3. Upper Division/Graduate
4. Graduate

Staff & Faculty Rank

Faculty

1. Professor
2. Associate Professor
3. Assistant Professor
4. Instructor/Lecturer/Research Associate
5. Graduate Assistants

Nonacademic

1. Professional/Management
2. Technical/Craft
3. Clerical/Secretarial
4. Unskilled/Semi-Skilled

Instruction Types

1. Lecture
2. Recitation & Discussion
3. Laboratory & Demonstration Instruction
4. Other Instruction

Space Types

1. Classroom
2. Class Laboratory
3. Research Laboratory
4. Office and Conference
5. Library
6. Museum/Gallery
7. Audio/Visual
8. Data Processing/Computer
9. Armory
10. Clinic
11. Demonstration
12. Field Service
13. Athletic-Physical Education
14. Assembly
15. Lounge
16. Merchandising
17. Recreation
18. Residential
19. Dining
20. Student Health
21. Medical Care
22. Physical Plant

Figure 4.2: Dimensions of RRPM-1.3

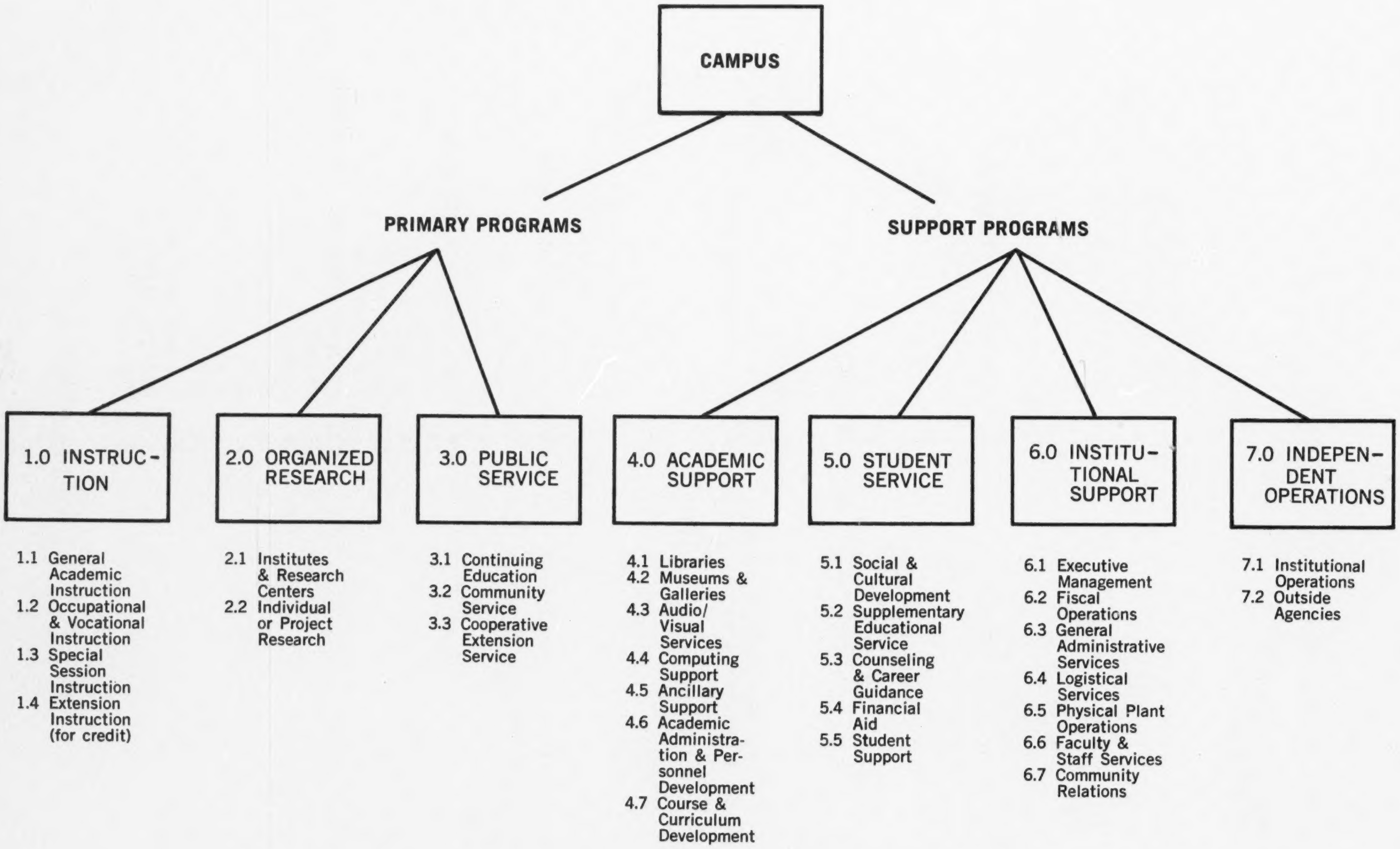

CAMPUS
PRIMARY PROGRAMS
SUPPORT PROGRAMS
1.0 INSTRUCTION
2.0 ORGANIZED RESEARCH
3.0 PUBLIC SERVICE
4.0 ACADEMIC SUPPORT
5.0 STUDENT SERVICE
6.0 INSTITUTIONAL SUPPORT
7.0 INDEPENDENT OPERATIONS
1.1 General Academic Instruction
1.2 Occupational & Vocational Instruction
1.3 Special Session Instruction
1.4 Extension Instruction (for credit)
2.1 Institutes & Research Centers
2.2 Individual or Project Research
3.1 Continuing Education
3.2 Community Service
3.3 Cooperative Extension Service
4.1 Libraries
4.2 Museums & Galleries
4.3 Audio/Visual Services
4.4 Computing Support
4.5 Ancillary Support
4.6 Academic Administration & Personnel Development
4.7 Course & Curriculum Development
5.1 Social & Cultural Development
5.2 Supplementary Educational Service
5.3 Counseling & Career Guidance
5.4 Financial Aid
5.5 Student Support
6.1 Executive Management
6.2 Fiscal Operations
6.3 General Administrative Services
6.4 Logistical Services
6.5 Physical Plant Operations
6.6 Faculty & Staff Services
6.7 Community Relations
7.1 Institutional Operations
7.2 Outside Agencies

Figure 4.3: Organization of NCHEMS' Program Classification Structure

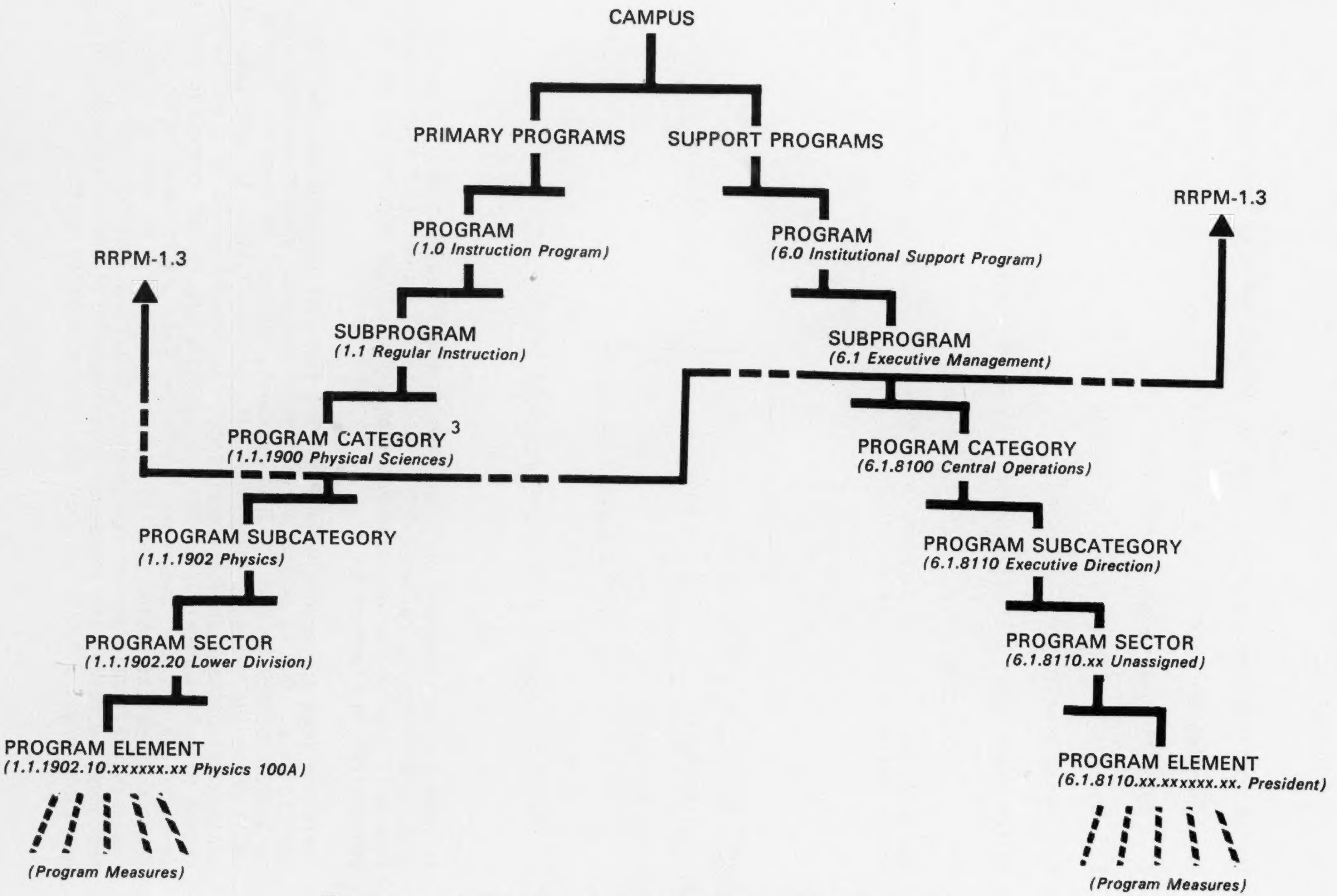

CAMPUS
PRIMARY PROGRAMS
SUPPORT PROGRAMS
PROGRAM
(1.0 Instruction Program)
PROGRAM
(6.0 Institutional Support Program)
RRPM-1.3
RRPM-1.3
SUBPROGRAM
(1.1 Regular Instruction)
SUBPROGRAM
(6.1 Executive Management)
PROGRAM CATEGORY 3
(1.1.1900 Physical Sciences)
PROGRAM CATEGORY
(6.1.8100 Central Operations)
PROGRAM SUBCATEGORY
(1.1.1902 Physics)
PROGRAM SUBCATEGORY
(6.1.8110 Executive Direction)
PROGRAM SECTOR
(1.1.1902.20 Lower Division)
PROGRAM SECTOR
(6.1.8110.xx Unassigned)
PROGRAM ELEMENT
(1.1.1902.10.xxxxxx.xx Physics 100A)
PROGRAM ELEMENT
(6.1.8110.xx.xxxxxx.xx. President)
(Program Measures)
(Program Measures)

Figure 4.4: Scope of RRPM-1.3 in the Program Classification Structure

Anticipated modifications to RRPM-1.3 can be classified into four main types:

1. Changing the support cost functions
2. Changing dimensions of variables
3. Doing some calculations differently
4. Using institutional sub-models

Each of the above types of modification will be discussed in turn below.

4.2.1 Cost Functions for Support Costs

The cost functions for support costs shown in Figure 4.1 are in very general form. One is reproduced in Figure 4.5.

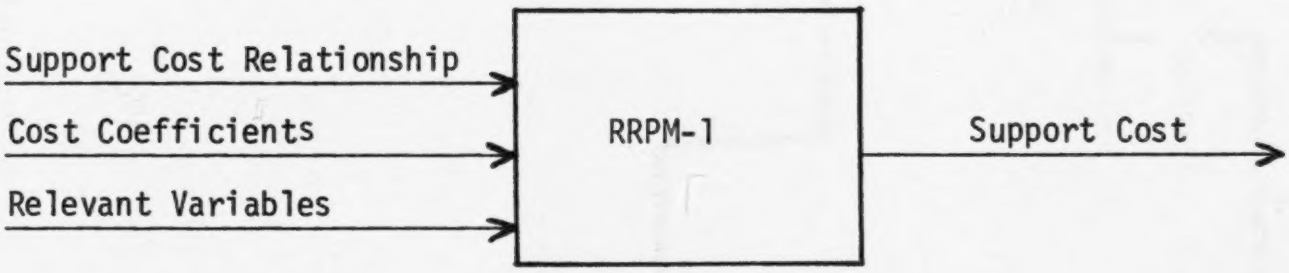


Fig. 4.5: General Form of Support Cost Calculation

In RRPM-1.3 each support cost function is specified, but it is expected that it will not be relevant for many institutions and that each institution will provide its own cost function. Hence, the representation is generalized in Figure 4.1.

There are many approaches to determining the cost function and the cost coefficients. One is to use a statistical computer program package such as GEORGE, BIOMED or ECON.[5] This approach, however, is feasible only in cases where the relevant historical data are available. In some cases the statistical package is not appropriate. An example would be a new institution with historical data that are unstable and do not represent trends. In this case and the case where historical data are not available, the functional relationships must be derived.[6] This can be done by a team of analysts (statisticians or management science and institutional research personnel) working with personnel knowledgeable of the relationship in question (e.g., a librarian when considering library costs).

The support cost relationships must be stated with great care to ensure that the institution is characterized analytically and that it will predict the support cost. The importance of this task cannot be overemphasized, and yet the difficulty of doing it should not be exaggreated. In one pilot institution, a statistical consultant working with institutional administrators stated the relationships and tested them successfully within a lapse time span of six weeks. Four other pilot institutions used administrative "judgement," while three used various statistical packages.[7]

4.2.2 Dimensions

The dimensions of RRPM-1.3 have been designed for the "typical" large institution of higher education. Therefore they are too large for many institutions, especially the four-year institutions and community colleges that have little or no Research or Public Service at the discipline level and fewer levels of students and courses than those allowed in RRPM-1.3. Reducing the dimensions will not only reduce the computer run-time but will also reduce core requirements, thereby making RRPM-1 available on smaller machines than currently possible. With this as the main objective, special versions of RRPM-1 have been designed. RRPM-1.4 is especially for community colleges, while RRPM-1.5 is for the four-year institutions. These versions are currently being implemented on a pilot basis. Their tentative dimensions are compared with those of RRPM-1.3 in Figure 4.6. (See page 18.)

The four-year institutions and community colleges that do not wish to wait for their specialized versions can, of course, use RRPM-1.3 but must pay for the extra memory occupied and additional runtime.

Institutions other than four-year colleges and community colleges may also wish to reduce their dimensions. More likely, however, they may wish to increase the dimensions in order to meet special institutional needs. This will require programming effort, extra core, and possibly longer run-times. The extra programming effort would be the order of 1-2 man weeks.

	RRPM-1.3	RRPM-1.4	RRPM-1.5
Audience	All Institutions of Higher Education	Community Colleges	4-Year Public Colleges
Noninstruction Program Research & Public Service	At Discipline Category	Not at Discipline Category	Not at Discipline Category
Instruction (Maximum Dimensions)			
Major	90	80	80
Disciplines	30 or 90	30	30 or 60
Student Levels	7	3	4
Course Levels	4	3	3
Faculty Ranks	5	4	5
Nonacademic Ranks	4	4	4
Instruction Types	4	4	4
Space Types	22	10	22
Core Required	150 K	≈128 K	≈128 K

Figure 4.6 Comparison of Dimensions for RRPMs 1.3, 1.4 and 1.5

4.2.3 Assumptions in Computations

RRPM-1.3 makes many assumptions throughout the model. Some of these may not be valid for the institution and must be modified. Consider for example the computation of Faculty FTE. The RRPM-1 assumptions as shown in Figure 4.1 are invalid in institutions that hire faculty according to a fixed ratio by ranks (required by law in some states in the U. S.). There are still other approaches to calculating faculty FTE that may be more appropriate to an institution. In these cases, the project manager must compare the cost of the modification against its benefits and make his choice.

4.2.4 Other Institutional Models

Some institutions may already have models for some special segments of their institutional operations. Examples would be a student flow model that predicts enrollment or a model that predicts costs of research. Such models could profitably be used as modules to the RRPM-1 provided the necessary interface is provided and the necessary modifications to RRPM-1 are made. In the case of a student flow model little modification is necessary. It can provide the student enrollment vector which is an exogenous variable to RRPM-1. In the case of the research cost model considerable programming effort will be necessary.

Thus far we have discussed the model and its modifications. Once its structure is settled, one must collect the data necessary to drive the model. This is the topic of the next chapter.

CHAPTER FIVE

DATA GENERATION

5.1 Introduction

Data required for RRPM-1 are implied in Figure 4.1. Details (including formats) necessary for data generation are given in the Input Specifications. In this Guide we are concerned with the overview of data generation with special attention to the sources of data, the data elements, and the validation of data. We are concerned with what type of data to collect. We are not concerned with how much data to collect, for that is a function of the strategy of model validation that will be discussed later. We are also not concerned here with file design or data structures, since they are beyond the scope of this Guide.

5.2 Data To Collect

The data needed for RRPM will be classified for the purposes of discussion into three (not mutually exclusive) types:

1. Data typically available
2. Estimation coefficients
3. Other independent variables

Each will be discussed in turn.

5.2.1 Data Sources

The data elements needed for calculating most of the variables in the RRPM-1 are typically available in institutional files for operational, if not managment decision-making, purposes. They are typically organized in the five files listed below:

1. Student File
2. Courses Taught File
3. Personnel File
4. Space File
5. Finance File

The institution may not have one of these files in machine readable form, in which case it may have to be created. This poses a choice. Should the file generate only the information needed by RRPM-1, or should it generate other related information that will be needed later by the institution? The latter alternative may be wiser in the long run but may not serve the needs of RRPM-1 in the short run.

If all the files exist, it may be that they are not all integrated. Integration of files is desirable and can be achieved by using a "linking" element in each file. The social security number is an example of a linking element. The Program Classification Structure (PCS) code is another. The PCS has two advantages: one, it is used by a large number of institutions of higher education in the U. S. reporting annually to the Federal government; two, it is basic to many other NCHEMS projects, especially the Information Exchange Procedures Project.

The linking files and a list of variables for RRPM-1.3 typically generated by these files are shown in Figure 5.1. The variable list for each file is only suggestive and would vary between institutions. For example, the space allocation factors can be generated by the Space File as shown in Figure 5.1 (see page 22) or by the Classes Taught File as was the case with one pilot institution (not shown in Figure 5.1).

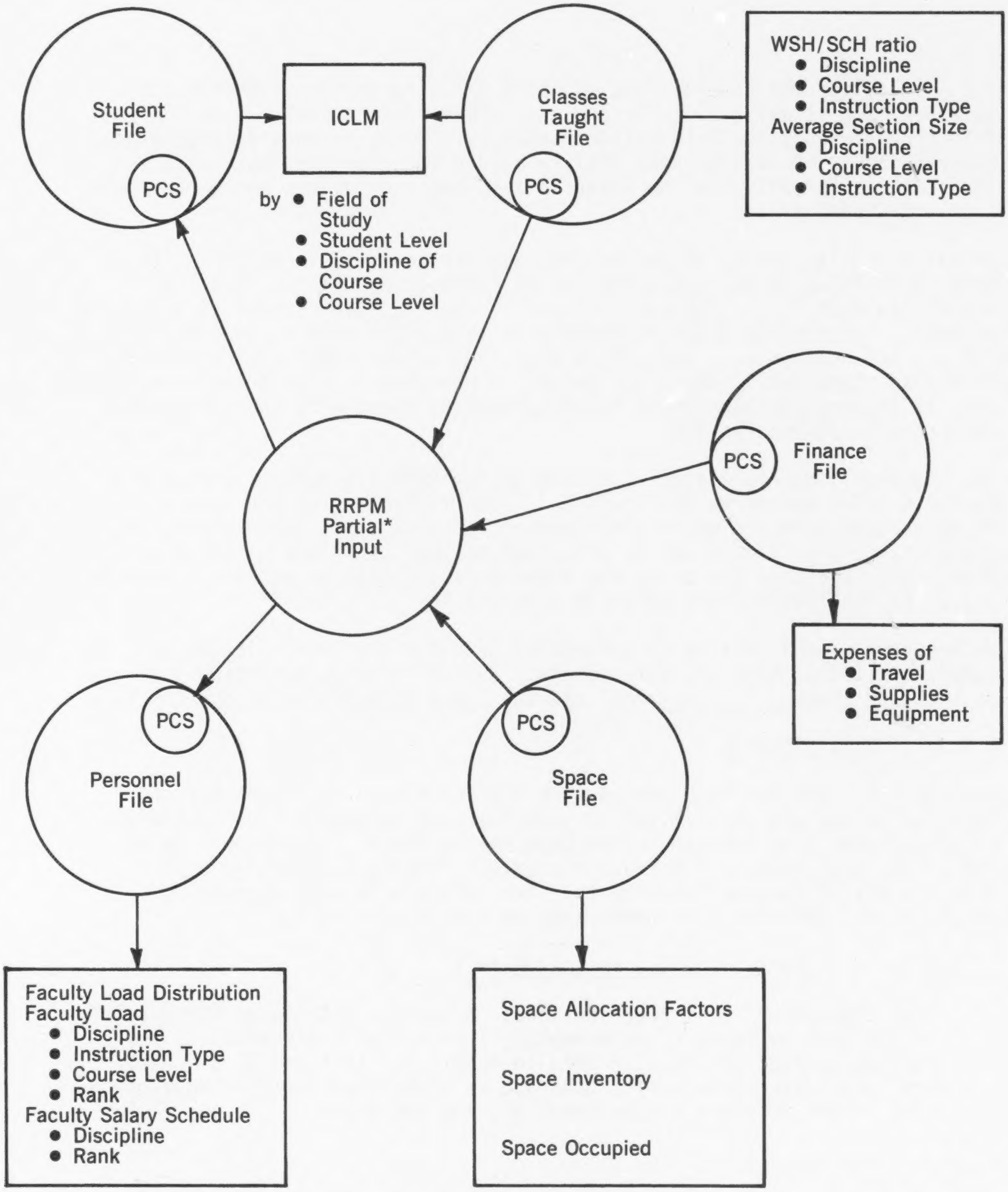
An essential consideration in generating data for the RRPM-1 is one of consistent definitions and terminology. This problem is addressed both in the Data Element Dictionaries[1] and the Space Manual[2] issued by NCHEMS.

5.2.2 Data Elements

Many of the variables required by RRPM-1.3 and listed in Figure 5.1 are familiar to one who is involved in institutional research. One variable is perhaps new, the Induced Course Load Matrix (ICLM). It happens to be one of the most important because its effect "ripples" throughout the calculations of instructional costs. The RRPM-1.3 is very "sensitive" to the ICLM. Therefore, it needs some explanation.

5.2.2.1 The Induced Course Load Matrix

This discussion is in four sections: Section I introduces the concept of the ICLM by means of an example. Section II is addressed to the representatives of the ICLM used in RRPM-1.3. Section III discusses the input data necessary to generate an ICLM. Section IV discusses some of the problems encountered in using the ICLM.



* This input is partial because it does not include estimation coefficients and exogenous variables

Figure 5.1: Data for RRPM-1.3 from Institutional Files

5.2.2.1.1 The Concept of ICLM

The ICLM is an important basic part of RRPM-1. It performs two functions in the model. First, it converts student enrollments by major into workloads on academic departments. These workloads, in turn, serve as the basis for all of the instructional resource and cost computations. Second, the ICLM provides a means of allocating departmental costs to student major programs.

The idea behind the ICLM and the calculations associated with it are straightforward and will be discussed by means of a brief example.

The first step in the computation of an ICLM is to obtain the student credit hours (SCH) generated by students of each major in all courses offered by each academic department on campus. Figure 5.2 shows a hypothetical example of such data for a campus with three departments and four majors.[3] It is assumed that all students carry a fifteen unit load and that all courses are lecture type and have a unit value of three. Further, in a certain fall semester ten students are enrolled in major program 1, twenty in major 2, thirty in 3 and ten in 4. These enrollment figures and the total number of student credit hours taken in all departments by each major are shown at the bottom of Figure 5.2.

Department	Major				Departmental SCH
	1	2	3	4	
1	75	60	90	45	270
2	30	120	90	60	300
3	45	120	270	45	480
Student Credit Hours By Major	150	300	450	150	1,050
Students By Major	10	20	30	10	70

Fig. 5.2: Student Credit Hours by Department & Major

Total SCH by department, a measure of departmental workload, is shown in the far right hand column. The entries in the body of the table are the units taken in each department by each major. As it stands the table presents some useful information regarding the sources of student demand for courses offered by each department (i.e., reading across a row of the table) and the demands placed upon all departments by students of a given major (i.e., reading down a column of the table).

Using the data in Figure 5.2, two alternative forms of the ICLM can be defined. (RRPM-1.3 will accept the ICLM in either form.) Both will be defined and discussed.

Department	Major			
	1	2	3	4
1	7.5	3.0	3.0	4.5
2	3.0	6.0	3.0	6.0
3	4.5	6.0	9.0	4.5
Totals	15	15	15	15

Fig. 5.3: ICLM, Alternative 1, Student Credit Hours Taken By the Typical Student of Each Major in Different Departments.

Figure 5.3 illustrates an ICLM obtained by dividing the entries in the body of Figure 5.2 by the headcount of majors also shown in Figure 5.2. It shows the units taken by the typical or average student in each major in the courses offered by each department. In this form the ICLM is used with projected student enrollment (headcount) data to project SCH by department. The calculation is illustrated in Figure 5.4. (The figures in parenthesis represent projected enrollments.)

DEPARTMENT	MAJOR				PROJECTED DEPARTMENTAL SCH
	1	2	3	4	
1	7.5(15) +	3.0(20) +	3.0(35) +	4.5(5)	= 300
2	3.0(15) +	6.0(20) +	3.0(35) +	6.0(5)	= 300
3	4.5(15) +	6.0(20) +	9.0(3.5) +	4.5(5)	= 525

Fig. 5.4: Illustration of Departmental Load Calculation Using ICLM Alternative 1.

Figure 5.5 illustrates an ICLM obtained by dividing the entries in the body of Figure 5.2 by total student credit hours by major shown at the bottom of Figure 5.2. It shows the relative distribution of units taken by students by each major over the course offerings of the departments.

Figure 5.6 illustrates the calculation of projected departmental SCH using projected student enrollment and average student load data. (The first figure in parenthesis is average student load, still assumed to be fifteen units for all majors; the second is projected enrollment.)

DEPARTMENT	MAJOR			
	1	2	3	4
1	.5	.2	.2	.3
2	.2	.4	.2	.4
3	.3	.4	.6	.3
Totals	1.0	1.0	1.0	1.0

Figure 5.5: ICLM, Alternative 2, Distribution of Major SCH Among Departments.

DEPARTMENT	MAJOR				PROJECTED DEPARTMENTAL SCH
	1	2	3	4	
1	.5(15)(15) +	.2(15)(20) +	.2(15)(35) +	.3(15)(5) =	300
2	.2(15)(15) +	.4(15)(20) +	.2(15)(35) +	.4(15)(5) =	300
3	.3(15)(15) +	.4(15)(20) +	.6(15)(35) +	.3(15)(5) =	525

Figure 5.6: Illustration of Departmental Load Calculation Using ICLM Alternative 2.

A column of the ICLM shows how students of a given major distribute their units among departments. This is precisely the information needed for allocating departmental unit costs to majors and programs. An illustration of such a computation (and other computations) is shown in the Appendix.

5.2.2.1.2 ICLM Representations

The ICLM used in RRPM is, of course, more detailed than the one used in the foregoing example. The RRPM will accept an ICLM having as many as 30 or 90 academic departments and 90 majors. Within a major there is provision for as many as seven student levels and within a department there is provision for as many as four course levels. Thus, a typical element of the ICLM used in RRPM might refer to the number of units taken by lower division economics students in upper division courses in history.

The four dimensions of an ICLM are shown algebraically below:

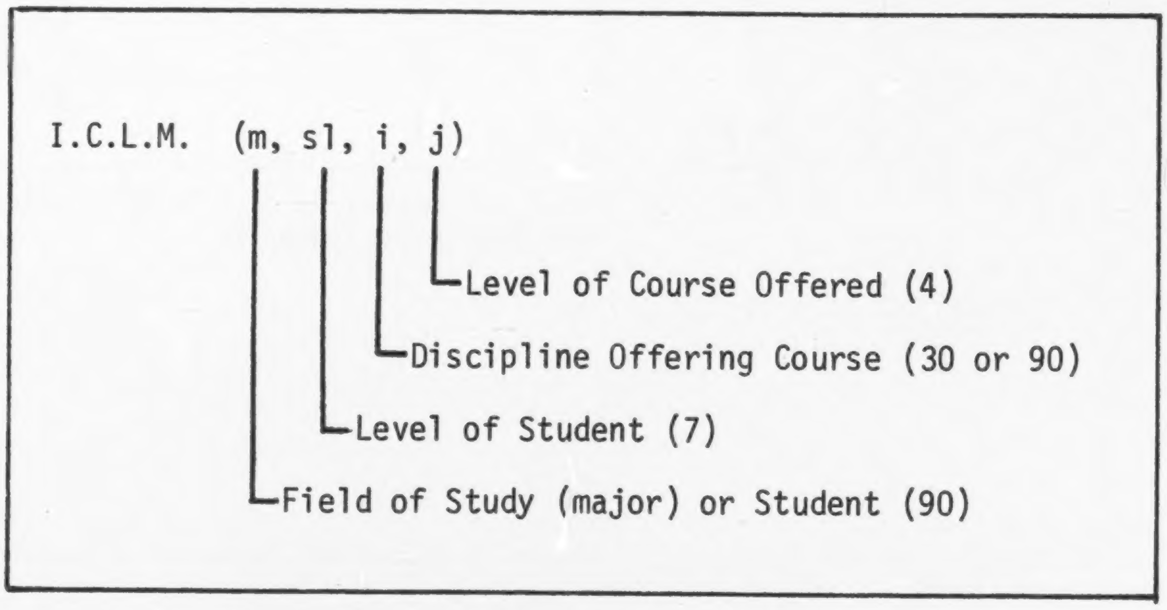

I.C.L.M. (m, sl, i, j)
Level of Course Offered (4)
Discipline Offering Course (30 or 90)
Level of Student (7)
Field of Study (major) or Student (90)

Figure 5.7: Dimensions of the ICLM

5.2.2.1.3 Generation of the ICLM

An ICLM can be generated from the following data on each student for each semester (or quarter):

1. Level of each course taken
2. Discipline of each course taken
3. Number of units of credit for each course
4. Major (or field of study) of student, and
5. Level of student

The above data can be used as input for computer program that will generate an ICLM with all the four dimensions as shown in Figure 5.7. (See page 26.) It can then be aggregated for diffrent dimensions or levels within each dimension. Such aggregation is useful in studying the stability characteristics of the ICLM, which is one of the important "problems" encountered in its use.

5.2.2.1.4 Some Reservations and Problems Concerning the ICLM[4]

Forecasting experience with the ICLM is limited. All of it is necessarily short run. Indications are, in general, that aggreate (campuswide) forecasts of SCH are quite accurate but that at the departmental level with student enrollments known, the forecasts may be in error by as much as ± 10 percent.

Errors in forecasts may arise from two sources: errors in projected student enrollment and errors in the ICLM, i.e., a failure of an ICLM based upon historical data to describe future student enrollment patterns. This failure is described as the problem of "instability" in the coefficients of the ICLM. This instability is revealed in the historical studies of the ICLM coefficients. The changes in the coefficients over time can be attributed to a large variety of causes such as scheduling problems, changing curriculum, changing major requirement and incorrect reporting of majors.[5]

The existence of these problems means that detailed forecasts based upon the ICLM--i.e., most of the variables forecast by RRPM at the program sector (departmental) level for the primary program regular instruction--should be interpreted with a good deal of caution[6] (and this caution should increase as the forecasting period increases).

Several investigators have speculated that an ICLM based upon data from more than one semester (or quarter) may provide more accurate forecasts than an ICLM based upon a single semester's data. Toward this end, the following schemes for defining the coefficients of a forecasting ICLM have been suggested:

1. A simple average of coefficients from several past periods.

2. An arbitrary weighted average of past coefficients with the last period having the largest weight.

3. An arbitrary weighted average of past coefficients with the similar period coefficients (e.g., Fall if Fall is the forecast period) having the largest weight.

4. A weighted average where the weights are student enrollments in the particular major and level.

5. Moving averages of past coefficients.

6. Forecast of the coefficient from a linear (or non-linear) regression of the past coefficients on a trend variable.

7. Definition of the coefficients as student contact rather than student credit hours.

Another line of investigation that may prove useful is concerned with the development of the statistical properties of the ICLM coefficients based upon the sample values provided by past data. Such a development would lead to interval rather than point estimates of the forecast variables. In any event, more investigation is needed on the definition of ICLM used for forecasting purposes. Admitting this difficulty it is clear that, at least for purposes of forecasting applications in the near future, check totals of departmental SCH should be derived by alternative (probably existing) techniques.

Although important from the standpoint of forecasting, the "stability problem" is less a liability when the ICLM is used in computing actual (past, historical) costs of major programs or when RRPM is used in the experimental mode where interest centers upon the difference between two forecast values of the dependent variables rather than their absolute levels.

5.2.3 Estimation Coefficients

Estimation coefficients are used extensively in calculating Support Expenses. These are calculated separately for both the academic and the nonacademic segments of the institutions. In both cases, the generalized form is typically linear and is as follows:

$$Y = a + bX$$

where Y = Support Expense

a = Constant cost efficient

b = Variable cost efficient

X = Relevant variable

a's and b's can be specified by management. Alternatively, if existing trends are to continue, then historical data may be used to determine the a's and b's by various approaches referred to earlier (Section 4.2).

The X's are often determined internally by the model, (e.g., faculty full-time equivalent by disciplines, SCH by discipline, etc.). If they are independent and not anticipated in the model (for example, the library on a campus serving the community has costs proportional to the number of industries or professionals in the city), then these independent variables must be provided.

5.2.4 Independent Variables

Independent variables[7] for RRPM-1.3 are identified in Figure 4.1. These variables, along with their dimensions, are shown in tabular form in Figure 5.8. (See page 30.)

The most important is student enrollment. Like the ICLM, its effect "ripples" throughout the instructional cost calculations. It also greatly affects nonacademic costs. Unfortunately it is very difficult to predict enrollment for future 5-10 years, especially by major and level of student as required by the RRPM-1.3. It is a function of student preferences, elasticity of the demand function for different institutions transfer rates between institutions, draft laws etc.

There are some formal approaches to predicting student enrollment.[8] One is being developed by NCHEMS and will be designed so that it can be used as a module to the RRPM-1. While awaiting such developments,[9] one must be content with traditional techniques of student enrollment predictions which in many cases are subjective and guesswork. In the case of the pilot institutions, two used their own student flow model; one used "judgment" only; and four used both.[10]

Some variables are referred to as planning variables. These are independent variables that are subject to management control in the process of planning. Theoretically, all the variables in RRPM-1 are planning variables, but typically there are only a few that should be changed or indeed can be changed. Some that can be changed have already been

DIMENSIONS / INPUT NAME	SUBPROGRAM	DISC/ DEPT	COURSE LEVEL	INSTRUC. TYPE	FACULTY RANK	NONACAD RANK	STUDENT LEVEL	STUDENT MAJOR
ICLM	X	X	X				X	X
Ratio of Student Cont/ Credit Hour	X	X	X	X				
Average Section Size	X	X	X	X				
Faculty FTE Distribution	X	X	X	X	X			
Average Faculty Load	X	X	X	X	X			
Salaries of Nonacad. FTE	X	X				X		
Salaries of Faculty FTE	X	X			X			
Growth Factors					X	X		
Average Total Student Credit Hour Load							X	X
Student Enrollments	X						X	X
Space Factors	X	X						
Estimation Equation Coefficients	X	X			X	X		

Figure 5.8: Summary of Institutional Inputs and Their Dimensions

mentioned: the estimation coefficients, the average number of credit hours taken by a student in a period of time, and the ICLM. Student enrollment could also be a planning variable in institutions that can "control" their admissions. Many institutions want to or must admit all who wish to enter, and enrollment is not under control. There may be a desired value or a desired range which can be used in RRPM-1.3 for determining the consequences of the different alternatives.

To facilitate changing the value of a variable or any element of it, a Pre-Processor is provided with the RRPM-1.3. It performs other functions of data generation besides data modification. It is the topic of most of the remaining part of this chapter.

5.3 Pre-Processor

The Pre-Processor to RRPM-1.3 is in three parts. Each is run independently and in a prescribed sequence. Each performs part of the general function of data generation and hence is referred to as a Partical Pre-Processor (acronym used henceforth will be PPP). The three Partial Pre-Processors and their functions are listed below:

PPP1: Reference Reports and diagonstics of errors.

PPP2: Reports for checking and analysis.

PPP3: Modification of data.

The role and relationship of the Partial Pre-Processors is illustrated in Figure 5.9. (See page 32.) Each will now be briefly discussed for its nature and function.

5.3.1 PPP1

The PPP1 analyzes the input to RRPM-1 and generates seven reports. These are:

Report 1. Listing of input data

2. List of definite errors

3. List of possible errors

4. List of zero values

5. Decision Rules

6. Statistics by variables

7. Statistics by type of errors

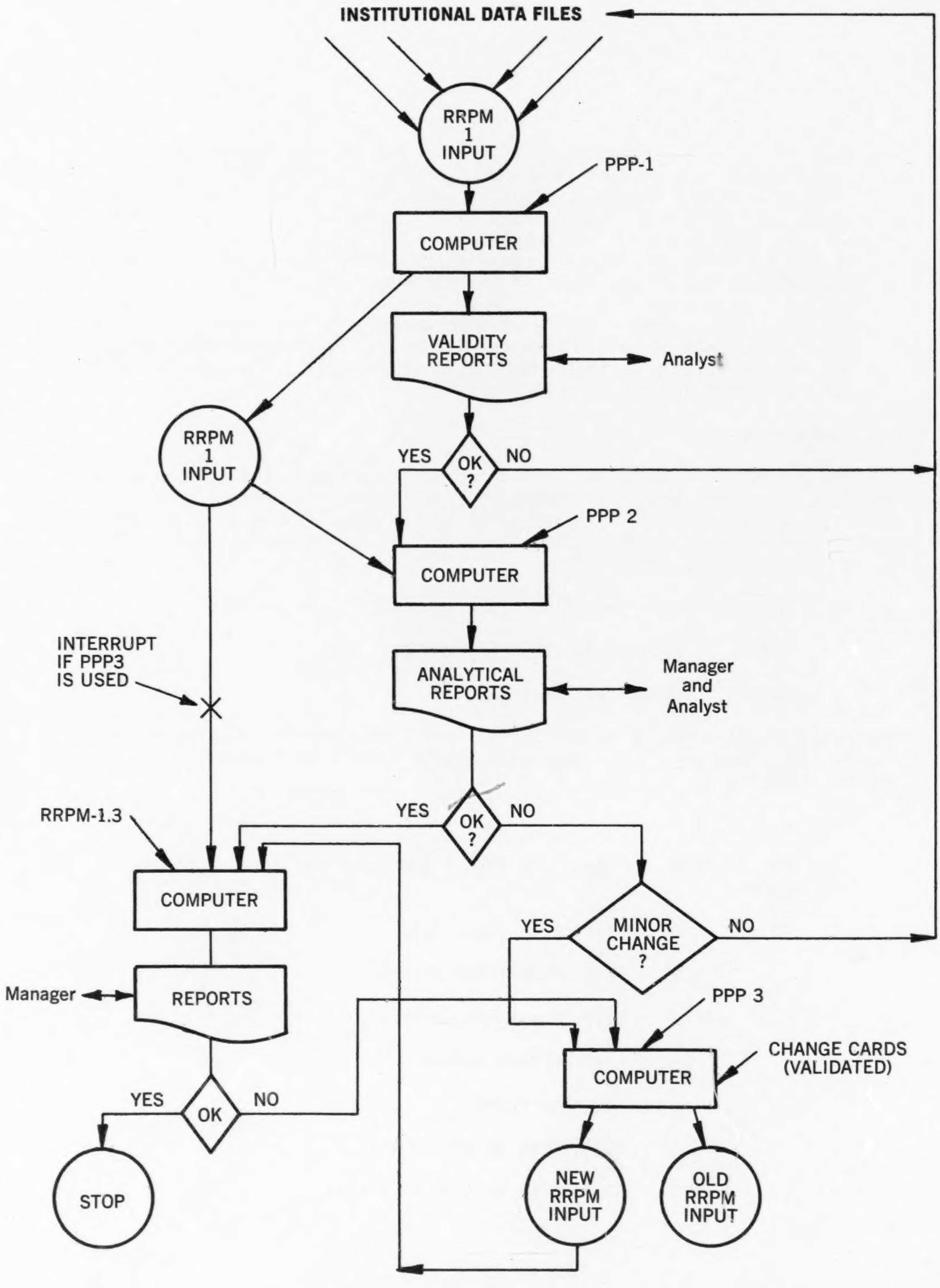


Figure 5.9: The Roles and Interrelationships of the Partial-Pre-processors

Report 1 lists the entire input in a decoded format identifying each data element. A sample of it is shown in Figure 5.10(a). It is designed to help identify errors and to be used as input to facilitate data correction. Another unexpected use made of this report by pilot institutions is that of displaying the values of each data element to management. The typical manager is skeptical of input in the form of magnetic spots on a tape. Seeing the english equivalent of these magnetic spots is very reassuring.

Reports 2 and 3 are diagnostic reports. For samples see Figure 5.10(b) and (c). Report 2 identifies "definite" errors that must be corrected (such as an alpha character in a numeric field, or vice versa); a missing value in a field that must have a value (e.g., no value for the average class size of a discipline that offers course); or a value that cannot occur (e.g., an average class size of 1 or less). A value can sometimes occur, but most unlikely (i.e., an average class size of 2 or 3). Such values are "possible" errors and are listed for further checking in Report 3. The values of ranges for both "possible" and "definite" errors will vary with institutions and are externally defined as parameters to the program. Each institution must prescribe the ranges appropriate for its institution. A list of the values used by the program is given in Report 5. (See page 35.)

Report 4 is a list of values that are recorded as zeros (see Figure 5.10(d)). They should be checked to ensure validity. Report 5 is a listing of the decision rules used in identifying "definite" and "possible" errors. These are defined by parameter cards. Reports 6 and 7 are an analysis of diagnostics and help to locate the type of error occuring. (For samples, see Figure 5.10(f), page 35 and (g) page 35 respectively.)

All reports in Partial Pre-Processor I (as with other Partial Pre-Processors) have a glossary identifying every abbreviation, acronym, or code used in the reports. A sample of such a glossary is shown in Figure 5.10(h). (See page 35.)

5.3.2 PPP2

If the PPP1 finds no "definite" errors and the "possible" errors are checked out, then the data are ready for analytical reports that are generated by PPP2. These reports are designed primarily to identify errors by sight-checking. They do, however, have a very important by-product: they provide an important source of information for analysis and institutional studies.

The PPP2 reports are generated only for the instructional data and only for selected variables. The reports are of two types. One type displays the value of one time period and for all disciplines. For example, the average class size for all disciplines at different levels of offerings in each of the different types of instruction. This enables an analyst and a manager to identify deviations from a mean or stated norm. The

```
                                                     RRPM PRE-PROCESSOR
                                                  LISTING OF INPUT DATA                                    REPORT  1    (a)
                                                                                                           PAGE    1
                       ICLM(M,K,I,J):  THIS IS THE INDUCED COURSE LOAD MATRIX FOR REGULAR INSTRUCTION.
                                       M IS THE NUMBER OF MAJORS, K IS THE NUMBER OF LEVELS OF
                                       STUDENTS, I IS THE NUMBER OF DISCIPLINES; AND J IS THE LEVELS OF
                                       CLASSES.

                                   J=1        J=2        J=3        J=4                                   CARD
                                                                                                          NO.
--------------------------------------------------------------------------------------------------------------------------

                               BY OFFICE-CONFERENCE SPACE TYPE IO.
ICLM  (01 ,01 ,01 , J)                 .001       .010        .1         1.0                                01
ICLM  (01 ,01 ,02 , J)              10.        100.        10.        10.                                   01
ICLM  (44 ,04 ,42 , J)            .0009        -32.        10.        10.                                   01
```

```
                                                   RRPM-1 PRE-PROCESSOR
                                                      DATE:  10/12/71                                        REPORT 2  (b)
                                                 LIST OF DEFINITE ERRORS                                     PAGE   1
                          IMAGE OF ERROR CARD RECORD                                             ERROR MESSAGE

  ICLM          10.     100.       10.      10.                       01  010102                     FOR ICLM
                   21>||||||||||<30                                                DATA VALUE DEFINITELY IN ERROR
             .0009     -32.        10.      10.                       01  440442*                    FOR ICLM
                   21>||||||||||<30                                                UNALLOWABLE CHARACTER(S) IN DATA FIELD
             .0009     -32.        10.      10.                       01  440442*                    FOR ICLM
                                                                       75>||<76    INDICES OUTSIDE BOUNDARIES GIVEN BY USER
                                                                                                     FOR WSHCO
                                                                                   REQUIRED VALUE MISSING
                                                                                                     FOR AVESEC
```

```
                                                   RRPM-1 PRE-PROCESSOR
                                                      DATE:  10/12/71                                        REPORT 3  (c)
                                                 LIST OF POSSIBLE ERRORS                                     PAGE   1
                          IMAGE OF ERROR CARD RECORD                                             ERROR MESSAGE

  ICLM          10.     100.       10.      10.                       01  010102                     FOR ICLM
         11>||||||||||<20                                                          DATA VALUE POSSIBLY IN ERROR
```

```
                                                      DATE:  10/12/71                                        REPORT 4  (d)
                                                   LIST OF ZERO VALUES                                       PAGE   1
                          IMAGE OF ERROR CARD RECORD                                             ERROR MESSAGE
ACASAL                .01      0.0        .10      1.00      10.00          07  000000                   FOR ACASAL
                   21>||||||||||<30                                                THE VALUE IS ZERO
DISICL      .010  .100  1.000 10.000100.     1000.         .001             0911000041                   FOR DISICL
                                                        61>||||||||||<70           THE VALUE IS ZERO
```

Figure 5.10: Samples of Partial Pre-Processor I (1 of 2 pages)

```
DATE:  10/12/71                          RRPM-1 PRE-PROCESSOR                                                       REPORT 5
                                           DECISION RULES                                                           PAGE   1
                                       VALID AND POSSIBLE LIMITS
                  VALID MAXIMUM       VALID MINIMUM         POSSIBLE MAXIMUM       POSSIBLE MINIMUM    CARD NUMBER
ICLM                  5.000
WSHCO                 2.000              0.000                 10.000                 0.000              01
DIVCO                 1.000              0.000                  4.000                 0.000              02
                                         0.000                  1.000                 0.000              04
```

(e)

```
                                         RRPM-1 PRE-PROCESSOR                                                       REPORT 6
                                          DATE:  10/12/71                                                           PAGE   1
                                          STATISTICS ON DIAGNOSTICS
                                        STATISTICS BY VARIABLES
                                                     ERROR  CODE TYPE
VARIABLE   VARIABLE    CODE 1    CODE 2    CODE 3    CODE 4    CODE 5    CODE 6    CODE 7    CODE 8    CODE 9
  NAME      NUMBER

WSHCO        02          1         0         5         1         0         1         0         0         0
DIVCO        04          0         1         0         0         0         0         0         0         0
FACLD        05          3         0         0         6         0         0         0         0         0
NACSAL       06          3         0         0         7         3         0         0         0         0
```

(f)

```
                                         RRPM-1 PRE-PROCESSOR                                                       REPORT 7
                                          DATE:  10/12/71                                                           PAGE   1
                                          STATISTICS ON DIAGNOSTICS
             ERROR MESSAGE                TOTAL STATISTICS
                                                                     CODE        NUMBER OF ERRORS
UNALLOWABLE CHARACTER(S) IN DATA FIELD
REQUIRED VALUE MISSING                                                1                 54
DATA VALUE POSSIBLY IN ERROR                                          2                  1
                                                                      3                 11
```

(g)

```
                                         G L O S S A R Y

        ABBREVIATIONS AND SYMBOLS USED.

          *           THIS CHARACTER IS USED IN REPORTS 2 AND 3 TO INDICATE MORE
                      THAN ONE ERROR ON THE SAME CARD.

          NO.:        THIS IS USED IN REPORT 1 FOR NUMBER.

          ><:          THESE CHARACTERS ARE USED AS POINTERS IN REPORTS 2, 3, AND 4.

        ERROR CODES USED IN REPORT 5.

          CODE 1:     UNALLOWABLE CHARACTER(S) IN DATA FIELD.
```

(h)

Figure 5.10: Samples of Partial Pre-Processor II (continued 2 of 2 pages)

second set of reports displays the value of the selected variables over previous years and identifies trends. Both sets of reports help in suggesting desirable changes for variables that could then be used in simulating values of the consequences. Samples of these reports for one variable are shown in Figure 5.11(a), and (b), similar reports are generated for eight other selected variables.[11]

5.3.3 PPP3

The Partial Pre-Processor 3 has been mentioned in connection with changing values of planning variables before making a "run" such as a modification to a variable made to generate the answer to a "what if" question. PPP3 is also used in generating data, especially after PPP1 and PPP2 identify errors. PPP3 then modifies the RRPM-1.3 input file to correct errors.

PPP3 can change any one or more variables or any one or more elements in a variable. The variable must be identified by a specified number and the data element by its index or indices. Changes that can be made are of three types:

a) A percentage change

b) An absolute value added or subtracted

c) A replacement by another value

Each change must be identified in a card image and there is a validity program that checks for the validity of each "change" card.

The output of PPP3 is a new input file on tape. A listing is produced for reference and is of the same format as listings of PPP1 shown as a sample in Figure 5.10(a). (See page 34.)

5.4 Control Totals

Very often an error is caused by inconsistency of input. A variable value could be incorrect and yet not be detected by the VALIDITY programs of institutional files or the Partial Pre-Processor 1 because it is within a permissible range. And yet, this error can be compounded and result in a significant error in the final output. To detect many such errors, one should compare totals of crucial variables derived from more than one source of raw data. For example, the Student Credit Hours, Student Headcount, and Student Contact Hours for each discipline can be computed from student data and compared with the same variables derived from data on courses taught. Similarly the FTE per discipline derived from personnel data can be compared with that derived or approximated from Classes Taught data. A mismatch detected must then be corrected.

```
                                        PRE-PROCESSOR II                                                                   PP2 REPORT 1
                                        RRPM-1 VERSION II                                                                  PAGE        1

                                    PM-I INPUT VARIABLE DISPLAY
                          DATE OF RUN: 09/02/71              YEAR OF INPUT DATA: 1968
                    RATIO OF WEEKLY STUDENT CONTACT HOURS/STUDENT CREDIT HOURS

                               CLASS ROOM INSTURCTION              LAB INSTRUCTION                     OTHER

        DISCIPLINE        PCS        LEVEL OF COURSE                    LEVEL OF COURSE                    LEVEL OF COURSE
           NAME           CODE  PREP  L-DEV  U-DEV  UD/GR  GRAD  PREP  L-DEV  U-DEV  UD/GR  GRAD  PREP  L-DEV  U-DEV  UD/GR  GRAD
-------------------------------------------------------------------------------------------------------------------------- ----

  AGRICUL. & NATURAL RESOR  100  0.0   0.0    0.0    0.0    0.0   0.0   0.0    0.0    0.0    0.0   0.0   0.0    0.0    0.0    0.0
ARCHITEC. & ENVIRON. DESIGN 200  0.0   0.0    0.0    0.0    0.0   0.0   0.0    0.0    0.0    0.0   0.0   0.0    0.0    0.0    0.0
       AREA STUDIES         300  0.0   0.0    0.0    0.0    0.0   0.0   0.0    0.0    0.0    0.0   0.0   0.0    0.0    0.0    0.0
    BIOLOGICAL SCIENCES     400  0.0   0.77   0.0    0.0    0.0   0.0   0.76   0.0    0.0    0.0   0.0   0.0    0.0    0.0    0.0
     BUSINESS & MGMT.       500  0.0   1.00   0.0    0.0    0.0   0.0   0.49   0.0    0.0    0.0   0.0   0.0    0.0    0.0    0.0
      COMMUNICATIONS        600  0.0   0.67   0.0    0.0    0.0   0.0   1.00   0.0    0.0    0.0   0.0   0.0    0.0    0.0    0.0
COMPUTER & INFO. SCIENCES   700  0.0   0.0    0.0    0.0    0.0   0.0   0.0    0.0    0.0    0.0   0.0   0.0    0.0    0.0    0.0
         EDUCATION          800  0.0   1.00   0.0    0.0    0.0   0.0   0.0    0.0    0.0    0.0   0.0   0.0    0.0    0.0    0.0
```

(a)

```
                                        PRE-PROCESSOR II                                                                   PP2 REPORT 1
                                        RRPM-1 VERSION II                                                                  PAGE        7

                                    PM-I INPUT VARIABLE DISPLAY
                    RATIO OF WEEKLY STUDENT CONTACT HOURS/STUDENT CREDIT HOURS

                                        LAB INSTRUCTION

                                        LEVEL OF COURSE
                                        LOWER DIVISION

          DISCIPLINE                 PCS          1968            1969            1970
             NAME                    CODE
---------------------------------------------------------------------------------------------------------------------------

AGRICULTURE AND NATURAL RESOURCES     100         0.0             0.0             0.0
ARCHITECTURAL AND ENVIRONMENTAL DESIGN 200        0.0             0.0             0.0
AREA STUDIES                          300         0.0             0.0             0.0
BIOLOGICAL SCIENCES                   400         0.76            0.61            0.75
BUSINESS AND MANAGEMENT               500         0.49            0.49            0.39
COMMUNICATIONS                        600         1.00            1.00            1.00
```

(b)

Figure 5.11: Samples of Partial Pre-Processor II

The comparison of check-totals is illustrated in Figure 5.12. (See page 39.) Comparison can be made by glance checking the hard copy reports or by a computer program. An example of the latter, comparing Student Headcount and Student Credit Hours from two files, is shown in Figure 5.13. (See page 40.)

5.5 Correcting Errors

The Control Totals, like the Pre-Processor, can detect errors in the early stages of their occurrences. These errors result in one or more of the following elements of data generation: transcribing, coding, following procedures, understanding file design and definitions, omissions, duplications, different census data and time periods for data relevance, joint product and joint costs. Resulting errors must be detected, traced, and corrected. Until then the RRPM program should not be run because it will result in considerable effort tracing the errors in the output and a waste of computer time running useless RRPM reports.

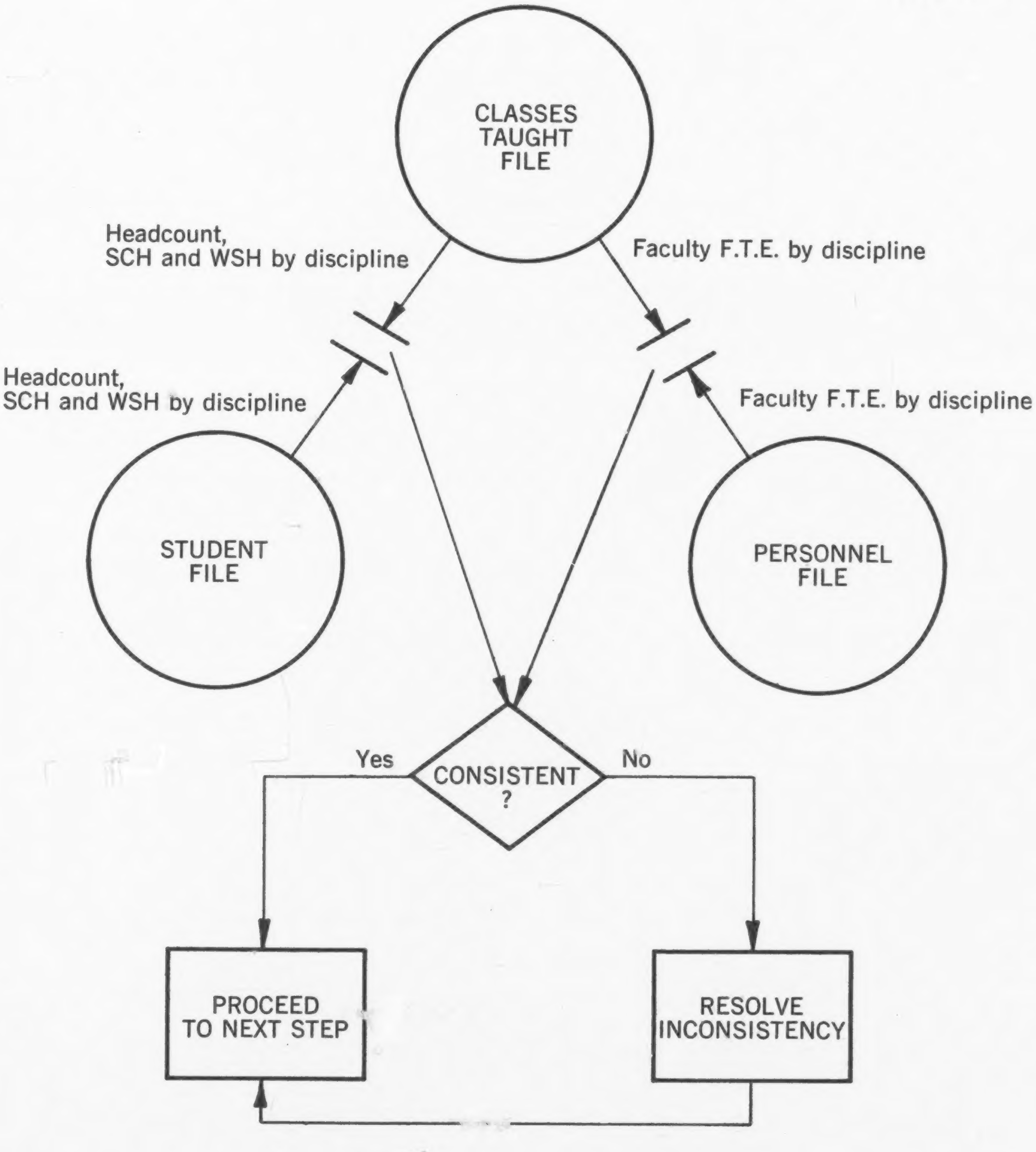

CLASSES TAUGHT FILE
Headcount, SCH and WSH by discipline
Faculty F.T.E. by discipline
Headcount, SCH and WSH by discipline
Faculty F.T.E. by discipline
STUDENT FILE
PERSONNEL FILE
Yes
CONSISTENT ?
No
PROCEED TO NEXT STEP
RESOLVE INCONSISTENCY

Figure 5.12: Checking Totals for Consistency

```
RUN DATE:    9/20/71              COMPARSON OF TOTAL STUDENT CREDIT HOURS AND  HEADCOUNT                  COMPARISON
                                  BETWEEN SCRF-3 AND CTRUF-1 BY EACH DEPARTMENT FOR THE                     PAGE  1
                                  SEMESTER:
                                              SPRING  - 1970

                                   DEPT  || CTRUF-1 | SCRF-3  |ABSOLUTE |  ERROR  ||     || CTRUF-1 | SCRF-3  |ABSOLUTE |  ERROR  ||
       DEPARTMENT  NAME            CODE  ||ST. CR HR|ST. CR HR|  DIFF   |    %    ||     ||HEADCOUNT|HEADCOUNT|  DIFF   |    %    ||
|--------------------------------------||---------|---------|---------|---------||     ||---------|---------|---------|---------||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|LANGUAGE AND JOURNALISM        (0001) || 1917.00 | 1992.00 |   75.00 |   3.765 ||     ||   667   |   697   |    30   |  4.304  ||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|--------------------------------------||---------|---------|---------|---------||     ||---------|---------|---------|---------||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|SOCIAL SCIENCES                (0002) || 2019.00 | 2016.00 |    3.00 |   0.149 ||     ||   673   |   672   |     1   |  0.149  ||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|--------------------------------------||---------|---------|---------|---------||     ||---------|---------|---------|---------||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|BUSINESS                       (0003) ||  579.00 |  549.00 |   30.00 |   5.464 ||     ||   193   |   183   |    10   |  5.464  ||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|--------------------------------------||---------|---------|---------|---------||     ||---------|---------|---------|---------||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|FINE AND APPLIED ARTS          (0004) ||  320.00 |  319.00 |    1.00 |   0.313 ||     ||   134   |   134   |     0   |  0.0    ||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|--------------------------------------||---------|---------|---------|---------||     ||---------|---------|---------|---------||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|EDUCATION                      (0005) ||  141.00 |  138.00 |    3.00 |   2.174 ||     ||    47   |    46   |     1   |  2.174  ||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|--------------------------------------||---------|---------|---------|---------||     ||---------|---------|---------|---------||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|PSYCHOLOGY                     (0006) ||  810.00 |  804.00 |    6.00 |   0.746 ||     ||   270   |   268   |     2   |  0.746  ||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|--------------------------------------||---------|---------|---------|---------||     ||---------|---------|---------|---------||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|SCIENCE                        (0007) || 1296.00 | 1436.00 |  140.00 |   9.749 ||     ||   328   |   363   |    35   |  9.642  ||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|--------------------------------------||---------|---------|---------|---------||     ||---------|---------|---------|---------||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|MATHEMATICS                    (0008) ||  837.00 |  838.00 |    1.00 |   0.119 ||     ||   269   |   269   |     0   |  0.0    ||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|--------------------------------------||---------|---------|---------|---------||     ||---------|---------|---------|---------||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|PRE-AGRICULTURE                (0009) ||    0.0  |    0.0  |    0.0  |   0.0   ||     ||     0   |     0   |     0   |  0.0    ||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|--------------------------------------||---------|---------|---------|---------||     ||---------|---------|---------|---------||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|PRE-MEDICAL AND PRE-DENTAL     (0010) ||    0.0  |    0.0  |    0.0  |   0.0   ||     ||     0   |     0   |     0   |  0.0    ||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|--------------------------------------||---------|---------|---------|---------||     ||---------|---------|---------|---------||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|PRE-ENGINEERING                (0011) ||    0.0  |    0.0  |    0.0  |   0.0   ||     ||     0   |     0   |     0   |  0.0    ||
|                                      ||         |         |         |         ||     ||         |         |         |         ||
|--------------------------------------||---------|---------|---------|---------||     ||---------|---------|---------|---------||
```

Figure 5.13: Examples of Control Totals of Head Count and SCH

CHAPTER SIX

VALIDATING THE MODEL

6.1 Introduction

In parallel to generating data, modifications to the model (if any) are to be made. (See Figure 2.1 page 3 .) After both these activities are completed the model must be validated. The strategies of validating the model, the stages of testing, and approaches to detecting problems are the topic of this chapter.

6.2 Validation Strategies

There are many approaches to verification of simulation models.[1] The one used by all pilot institutions implementing RRPM-1 was that of using historical data. The basic recycling process of using historical data for validation is shown in Figure 6.1. (See page 42.) The same recycling process with identification of the iterations that may be necessary is shown in Figure 6.2. (See page 43.) Note that after evaluation #1, the data on the input to RRPM had to be corrected, but the model and the accounting data did not change. After evaluation #2 the model changed, requiring a change in the data for the model and changes in the accounting data needed for evaluation.

RRPM is designed for a "typical institution," and its relevance to an institution may require changes to the structure of the model. Most often, however, the structural changes are required in the cost relationship of the support programs. Such a change is one of "form" rather than a change in data, which is a change in "content." A structural change of the "form" of the model typically requires changes in the data "content" --both data to run the model and data from the accounting system needed for comparison and evaluation.

In the general case as shown in Figure 6.2, there are "k" versions of model, "l" sets of data collected to run the model, "m" evaluations, and "n" sets of accounting data used. The most extreme case among the pilot institutions was where k=23, l=5, m=24 and n=9.

Figure 6.2 shows the need for accounting data on totals to correspond to totals predicted in the RPRM-1 output. This poses a serious set of problems. One problem is that the categories in the accounting data may not correspond to the program classifications used in RRPM-1, especially if the institutional Chart of Accounts has changed in the period being tested. The second possible problem is that the accounting data are by fiscal year and the annual data for the RRPM-1 are by academic year. A conversion of one to the other is necessary.

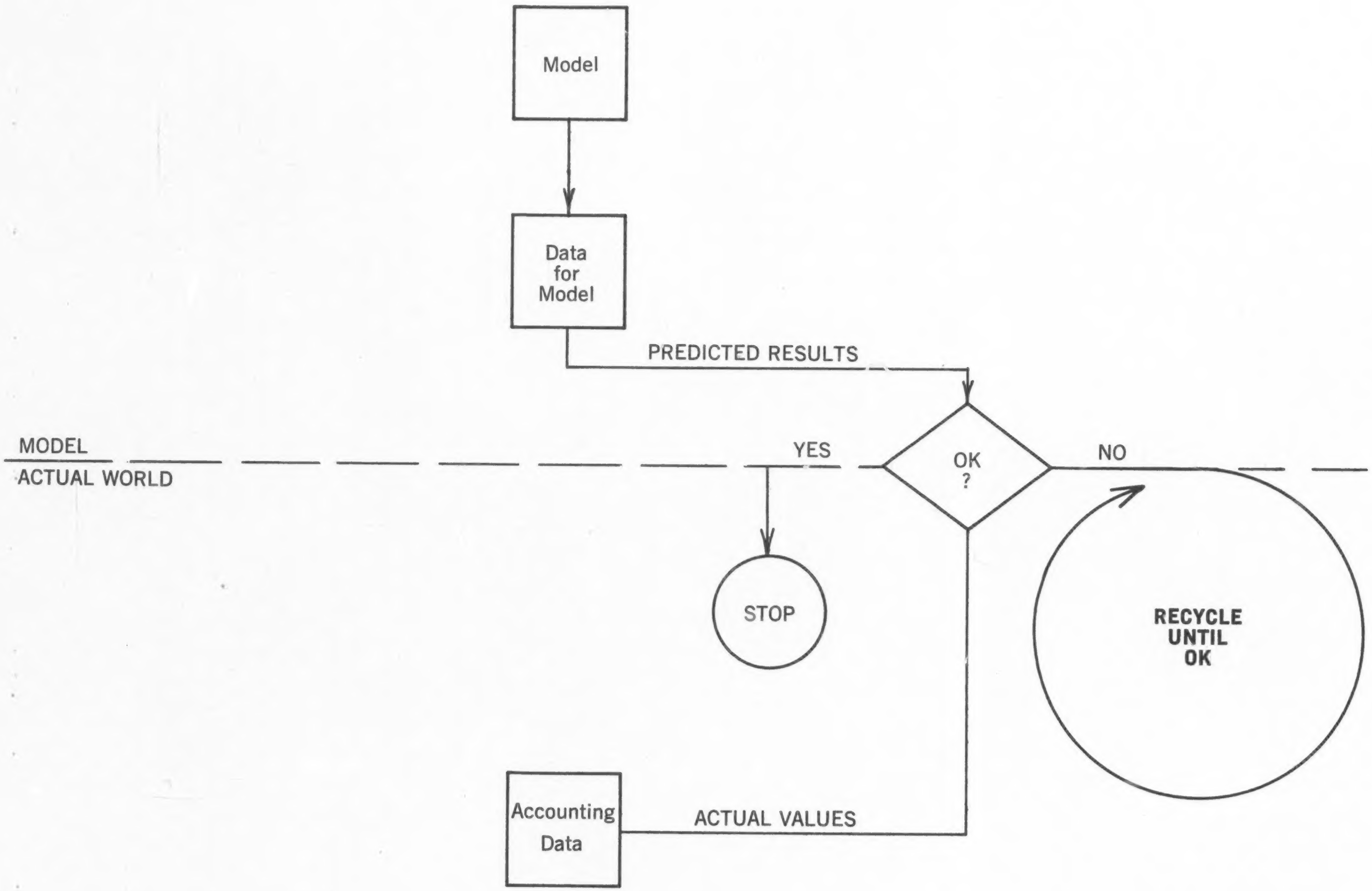


Figure 6.1: Process of Validation

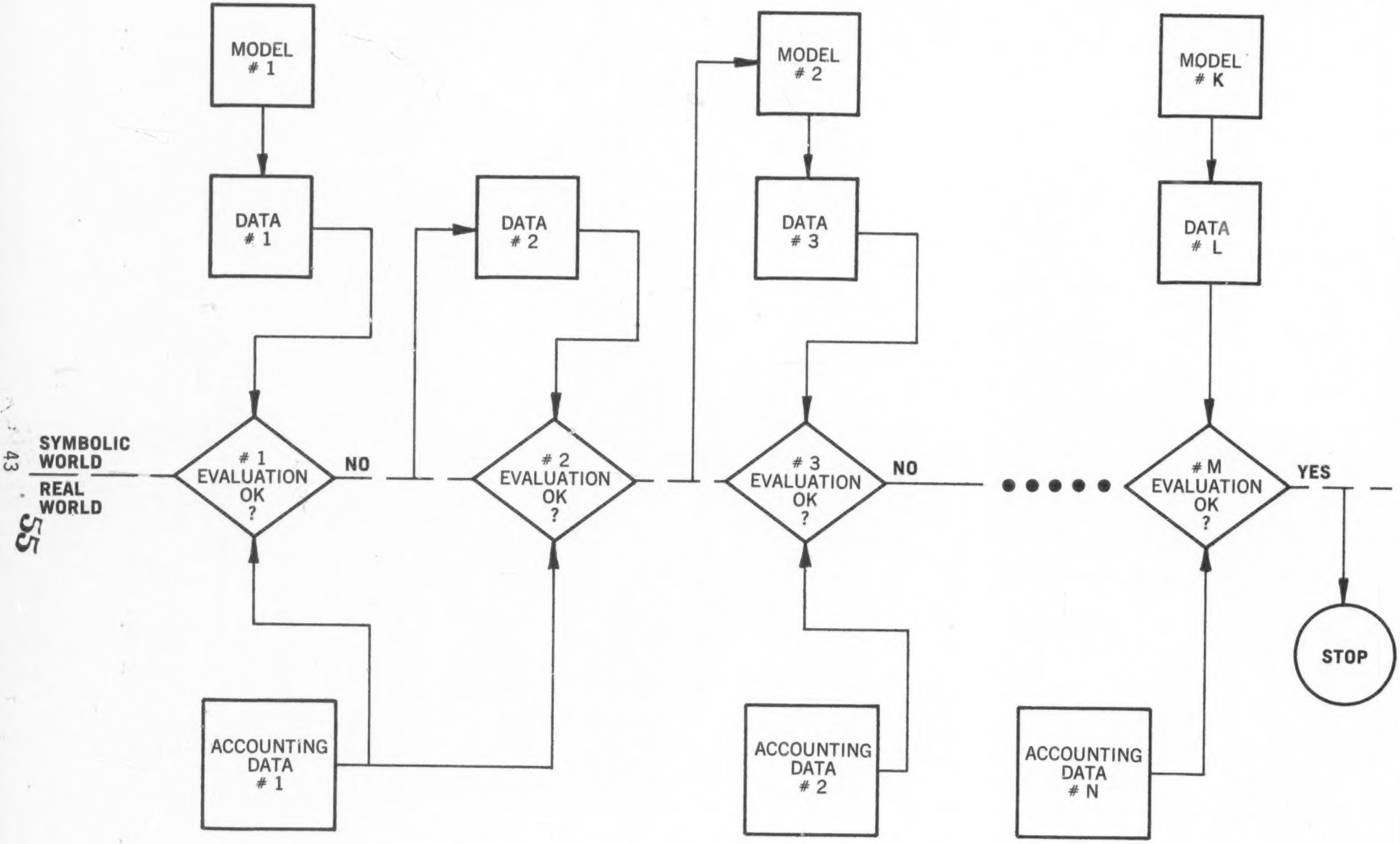


Figure 6.2: Iterations in Validation of Historical (accounting) Data

For the above reasons, the collecting of accounting data is often frustrating and time consuming. It must be scheduled in parallel to the activities of generating data for the model and modifying the model. Collection of accounting data is not shown in the diagram in Figure 2.1 (page 3) because of the danger that it will be confused with the activity of collecting data necessary for running the model.

The accounting data used for evaluating predicted results could be either historical, current, or both historical and current. The criticism of the historical data alone is that they may not represent the current or future state of operations; the objections to current data alone may be that they represent only a small sample and may not represent trends in an institution. Hence, the combination of historical and current data is typically the best solution if this is feasible.

6.3 Considerations of Experimental Design

The selection and comparison of historical data as a strategy of validation raises questions in experimental design. At what level of aggregation should the results be compared for validity? What sample should be taken? How many years of historical data should be tested? What levels of divergency between predicted and actual expenses should be allowed? Each of the above quesions should be answered with great care.

6.3.1 Level of Aggregation for Testing

The answer to this problem can be implied by the following case study. One pilot institution found its predicted annual budget was within ± 5 percent of the actual value. Closer analysis, however, showed over a 100 percent variation in two departmental budgets. These were in opposite directions and hence did not greatly affect the overall value. But the moral is clear: one must test at the level of aggregation at which resources are allocated and spent. This may be the departmental, division, or college level.

6.3.2 Sample Size

Should a sample of administrative units be taken for testing, and if so, what should be the size of the sample? The answer is again implied by the case above. Two compensating errors can go undetected; hence, the predicted budget of every administrative unit receiving and spending resources must be tested against the actual value.

6.3.3 Quantity of Data

Sometimes there is little choice. An institution may have only three years of data (accounting data or data to run the model or both). These data would suffice if the validation results were "reasonably" close. Anything less would be a point estimate and not very conclusive. It may be sufficient or it may satisfy one set of conditions but not necessarily another likely set of conditions.

What if there were data for 15 years? Should the model be tested for 15 years? Not necessarily so, because after a point, diminishing returns set in, and the cost of testing is not worth the information generated. This also may be true of much less than 15 years because past conditions may have been so different that they may no longer be applicable. Or maybe we do not want the model to be valid for the past because we do not want the model to duplicate the past. These are important considerations that must be examined before determining the quantity of historical data to be used for testing.

6.3.4 Standards of Testing

The closer the predictions come to the actual values, the better (barring spurious accuracy). However, in the first year of implementing RRPM-1, one should get within ± 5 percent for the annual overall budget and within ± 10 percent for each budget to which resources are allocated. There would be special cases, of course, and these must be examined individually. An example of an expected deviation would be the case of a small discipline or department. A relatively small absolute change in its results could produce a relatively large percentage result. This was true of disciplines 5 and 8 shown in Figure 6.3. (See page 46.)

The comparisons between actual and predicted values can be made by a computer program or by tabulation. The first method is expensive, the second is difficult to read and analyze. Another approach is to use a Quality Control Chart with Upper and Lower Control Limits identifying the maximum positive or negative variations allowed. Points representing percent variations are then plotted on the charts with points out of control quickly and graphically identified.

The Control Chart approach was used by one pilot institution. Its actual results for three years are shown for the instructional costs in Figure 6.3 (page 46) and the noninstructional costs in Figure 6.4. (See page 47.)

Note in Figure 6.4 that the budget for financial aids for the year of 1969-70 is out of control. An inquiry of the Financial Aids officer indicated this point to have been caused by a totally unexpected sudden source of funds, a condition that could not have been predicted by RRPM-1 or indeed any model. The point being outside the control limits was therefore considered not "significant" and "satisfactorily explained."

6.4 Phases of Testing

In a model like RRPM-1.3 that has many variables, including some whose values have to be predicted, it is desirable to do the testing in phases. One can start with only variables with certain values and progressively add more and more variables with uncertain values. This helps to isolate the problems and often makes the testing process consume less computer time and be less effort.

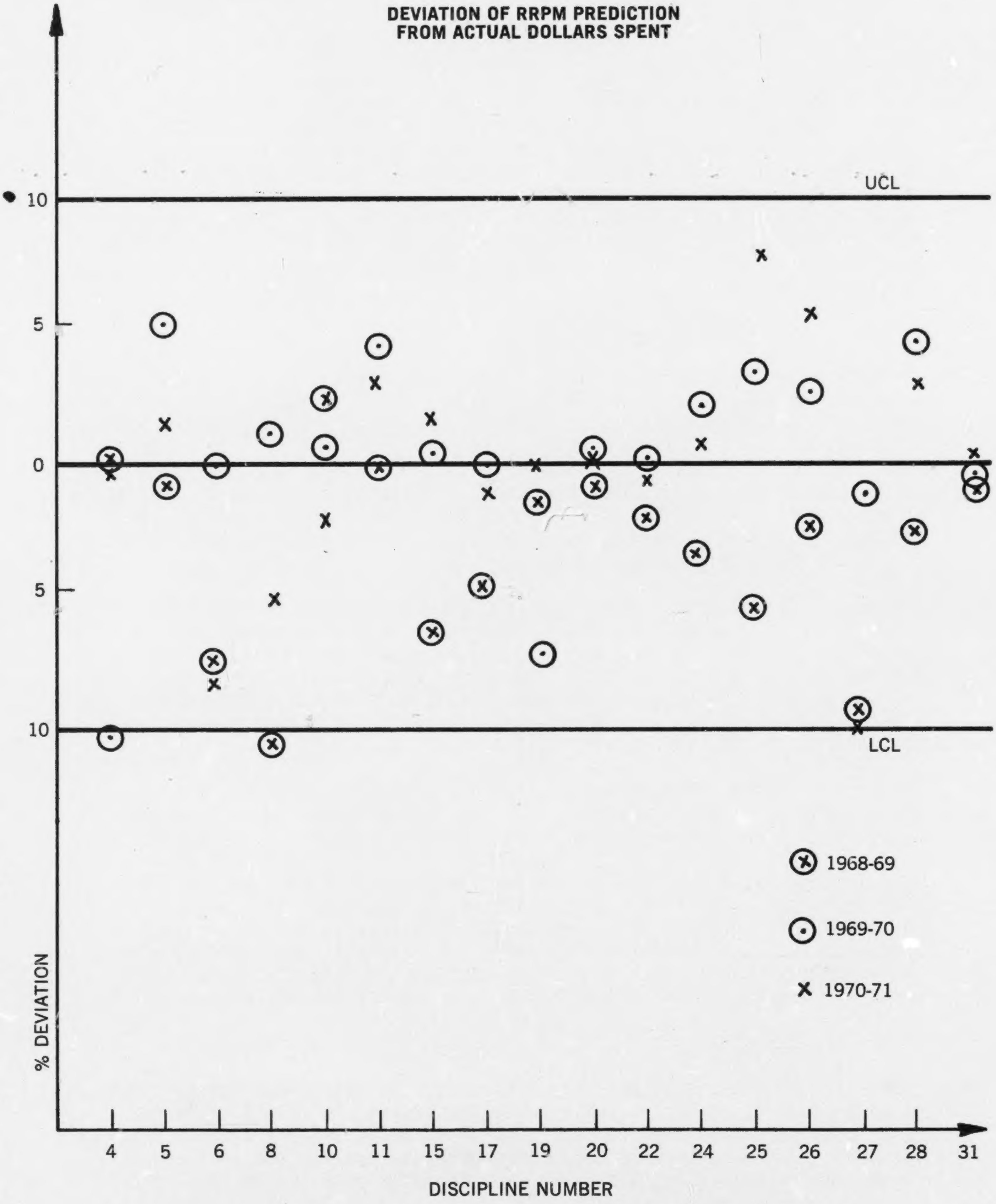


Figure 6.3: Comparison of Predicted and Actual Values (instructional program)

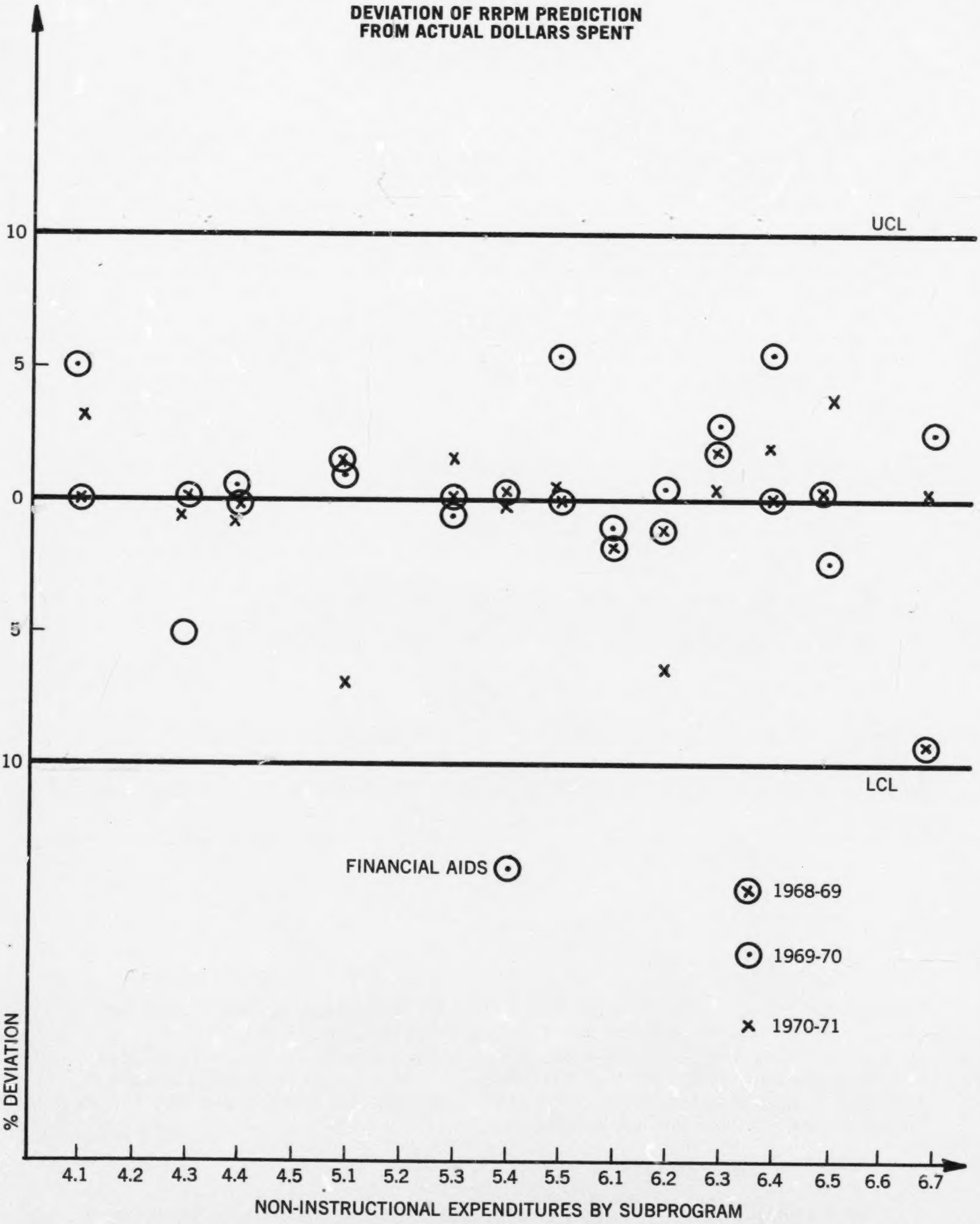


Figure 6.4: Comparison of Predicted and Actual Values (noninstructional programs)

Some phases of testing for RRPM-1.3 are suggested in Figure 6.5. (See page 48.) The first stage selects a base year and uses all known data for that year. If the model tests out satisfactorily, then one does the same for all years to be tested. If that phase is also satisfactorily accomplished, then one pretends to be in the year previous to the base year and predicts the base year. Herein appear the uncertainties of student enrollment, inflation factors, and the ICLM. They may be introduced collectively or, better still, separated by adding variables progressively. The ultimate state would be to pretend that one were predicting ten years (or as many years for which this is feasible and desirable), run the model for ten years, and then compare the results with ten years of historical data. This phase was not attempted by any pilot institution, largely due to lack of time available for the pilot testing.

1. Predict base year from known data for base year
2. Predict other years with data for these years.
3. Predict 1.) using data for $\text{year}_{\text{base -1}}$
4. Repeat 3.) for all years of testing period
5. Predict for up to X years of data from $\text{year}_{\text{latest predicted year -X}}$

Fig. 6.5: Phases of Testing

6.5 Detecting Problems

Getting the points to fall with the control limits requires much work and skill. It includes a desire for trouble shooting and problem solving, a good intuition, a systematic and logical mind, hard work, and a knowledge of the system (institution and the RRPM-1). To help in detecting problems, the RRPM-1 system has two special aids: intermediate output and the TRACER-TRAINER. Each is discussed below:

6.5.1 Intermediate Output

In a model like RRPM-1.3 with many interrelated variables, it is very difficult to isolate an error. It is important to identify error as early as possible so that it is not compounded and, if possible, to isolate it as being in a distinct "part" of the program, thereby reducing the "space" for searching. This is done by the intermediate output and is displayed in Figure 6.6. It identifies the results at different stages of the computations, facilitating early detection and isolation.

By way of illustration, suppose there were an error in the budget of the history discipline. One would then use the intermediate output and look at the faculty FTE for history. (See Figure 6.6(a) page 50), which determines the largest cost component of the instructional costs. If it were close to the actual value, the problem must be with the support costs (for partial sample see Figure 6.6(b) page 50) and most likely with the estimation equations or the cost coefficients. If the FTE computation were significantly wrong, one would look for the last crucial computation: SCH for history. If this were the fault, one would look at the inputs displayed by the PPP2. Other intermediate outputs not shown in Figure 6.6 include computations of nonacademic costs. These, as well as other intermediate results are printed in the same sequence in which they are computed.

Sometimes this does not help. If the input values look reasonable to the analyst, the problem may be caused by an exceptional situation about which the analyst is unaware. The person who could help here would be the department chairman of the discipline in question, (i.e., history in our illustration). He is best acquainted with his data. To help him find the error we need to "trace" the computations of the history discipline. This is one of the functions of the TRACER-TRAINER.

6.5.2 TRACER-TRAINER

Conceptually the TRACER-TRAINER is very simple. It is a series of WRITE statements interspersed in the RRPM-1 program displaying all the intermediate computations and inputs for any one specified discipline. Studying the output for his discipline, the department chairman can spot errors in the input that are within the legal value range and hence were not detected by either the PPP1 or the analyst.

The TRACER-TRAINER, like the intermediate output shown in Figure 6.6 also traces computations. The difference is that the intermediate output traces calculations for all disciplines, while the TRACER-TRAINER traces the computations for any selected discipline and identifies the inputs used in these computations.

The TRACER-TRAINER sample output is displayed in Figure 6.7. (See page 51.) It has another function, that of training the manager to use the model. Using the model is the subject of the next chapter; training the subject of the following chapter.

```
RRPM 1.3        INTERMEDIATE OUTPUT FOR YEAR  1       PAGE NO.   2        (a)
RUN NO.  3             BY INSTRUCTION TYPE               9/20/71

     **** STUDENT DATA ****    ********* FACULTY DATA **********
IN   CR.    CT/CR CT.     AVE.  CT.    RANK PER  CT.     LOAD   FTES
TYPE HOURS RATIO HOURS   SECT. HOURS        CENT HOURS


HISTORY        GRADUATE          INSTRUCTION

 1           0.375  174.1  28.0  6.22  1    0.35  2.18    8.00  0.27
                                       2    0.45  2.80    8.00  0.35
                                       3    0.20  1.24    8.00  0.16
                                       4    0.0   0.0     0.0   0.0
                                       5    0.0   0.0     0.0   0.0
                                            ----- -----         -----
                                            1.00  6.22          0.78
 2           0.536  248.9  20.0 12.44  1    0.35  4.36    8.00  0.54
                                       2    0.45  5.60    8.00  0.70
                                       3    0.20  2.49    8.00  0.31
                                       4    0.0   0.0     0.0   0.0
                                       5    0.0   0.0     0.0   0.0
                                            ----- -----         -----
                                            1.00 12.44          1.56
 3           0.089   41.3  10.0  4.13  1    0.35  1.45    8.00  0.18
                                       2    0.45  1.86    8.00  0.23
                                       3    0.20  0.83    8.00  0.10
                                       4    0.0   0.0     0.0   0.0
                                       5    0.0   0.0     0.0   0.0
                                            ----- -----         -----
                                            1.00  4.13          0.52
      ------ ----- ------        -----                          -----
       464.3 1.000  464.3        22.79                          2.85
      ------        ------       -----                          -----
      2694.0        2694.0      100.13                          9.97
```

```
RRPM 1.3        INTERMEDIATE OUTPUT FOR YEAR  2       PAGE NO.  68        (b)
RUN NO.  3             BY DISCIPLINE                     9/20/71

     DISCIPLINE    SUPPLY        TRAVEL       EQUIPMENT

  HISTORY       $ 3148.59  $ 2087.69    $ 1950.16
  ENGLISH       $ 3734.77  $ 2273.28    $ 2085.09
  MATHEMATICS   $ 1493.90  $  984.74    $ 2409.79
```

Figure 6.6: Samples of Intermediate Output

(a)

```
                       R R P M - 1   V E R S I O N   3
                  T R A C E R   /   T R A I N E R   P R O G R A M

      THIS PROGRAM TRACES THE STEPS AND COMPUTATIONS PERFORMED BY THE PM-1, PART 1
      MODULE OF RRPM-1.3 AND DISPLAYS EACH STEP FROM START TO FINISH, THE VALUES USED,
      THE INTERMEDIATE RESULTS AND THE FINAL OUTPUT FOR ANY CHOSEN DISCIPLINE.
      HEREAFTER WHEN THE TERM DISCIPLINE IS USED, IT INDICATES DISCIPLINE, DEPARTMENT
      OR DIVISION AS THE CASE MAY BE

                STUDENT LEVEL          STUDENT LEVEL
                   NUMBER                  NAME

                     1                  FRESHMEN
                     2                  SOPHOMORE
                     3                  SPECIAL

                FACULTY RANK           FACULTY RANK
                   NUMBER                  NAME
```

(b)

```
                                MODULE 3

                      INSTITUTIONAL CHARACTERISTICS MODULE

THE RATIO OF STUDENT CONTACT HOURS TO STUDENT CREDIT HOURS (CONTACT/CREDIT) BY COURSE LEVEL AND INSTRUCTION TYPE FOR
THE CHOSEN DISCIPLINE IS AS FOLLOWS:

NOTE: PLEASE SEE MODULE 1 FOR LISTS OF INSTRUCTION TYPES AND COURSE LEVELS.

                 INSTRUCTION  INSTRUCTION  INSTRUCTION  INSTRUCTION
                   TYPE 1       TYPE 2       TYPE 3       TYPE 4

COURSE LEVEL 1      0.571        0.357        0.072        0.0
COURSE LEVEL 2      0.480        0.400        0.120        0.0
COURSE LEVEL 3      0.375        0.536        0.089        0.0

THE AVERAGE SECTION SIZE (BY COURSE LEVEL AND INSTRUCTION TYPE) FOR THE CHOSEN DISCIPLINE IS AS FOLLOWS:

NOTE: PLEASE SEE MODULE 1 FOR LISTS OF INSTRUCTION TYPES AND COURSE LEVELS.

                 INSTRUCTION  INSTRUCTION  INSTRUCTION  INSTRUCTION
                   TYPE 1       TYPE 2       TYPE 3       TYPE 4

COURSE LEVEL 1     40.000       25.000       15.000        0.0
COURSE LEVEL 2     40.000       25.000       15.000        0.0
COURSE LEVEL 3     28.000       20.000       10.000        0.0
```

Figure 6.7: Samples of the TRACER-TRAINER Output (1 of 2 pages)

(c)

```
                                        MODULE 8

                              CALCULATION MODULE FOR YEAR 3

THE STUDENT CREDIT HOURS (BY COURSE LEVEL) FOR THE CHOSEN DISCIPLINE IS AS FOLLOWS:
PLEASE SEE MODULE 1 FOR LISTING OF COURSE LEVELS.

COURSE LEVEL 1  COURSE LEVEL 2  COURSE LEVEL 3  COURSE LEVEL 4

   1108.699        1121.049        464.300            0.0

THE TOTAL STUDENT CREDIT HOURS FOR ALL COURSE LEVELS FOR THE CHOSEN DISCIPLINE IS  2694.048

WEEKLY STUDENT HOURS (BY DISCIPLINE, COURSE LEVEL AND INSTRUCTION TYPE) = THE RATIO OF STUDENT COUNTACT
        HOURS TO STUDENT CREDIT HOURS (BY DISCIPLINE, COURSE LEVEL AND INSTRUCTION TYPE)
        (SEE MODULE 3) MULTIPLIED BY STUDENT CREDIT HOURS (BY DISCIPLINE AND COURSE LEVEL.

WEEKLY STUDENT HOURS (BY COURSE LEVEL AND INSTRUCTION TYPE) FOR THE CHOSEN DISCIPLINE IS AS FOLLOWS:

INSTRUCTION TYPE 1  INSTRUCTION TYPE 2  INSTRUCTION TYPE 3  INSTRUCTION TYPE 4


COURSE LEVEL 1            0.0                 0.0                 0.0                 0.0
COURSE LEVEL 2            0.0                 0.0                 0.0                 0.0
COURSE LEVEL 3            0.0                 0.0                 0.0                 0.0


THE WEEKLY FACULTY CONTACT HOURS BY DISCIPLINE, COURSE LEVEL AND INSTRUCTION TYPE) = WEEKLY STUDENT
        HOURS (BY DISCIPLINE, COURSE LEVEL AND INSTRUCTION TYPE) MULTIPLIED BY THE AVERAGE SECTION SIZE
        (SEE MODULE 3).

THE WEEKLY FACULTY CONTACT HOURS (BY COURSE LEVEL AND INSTRUCTION TYPE) FOR THE CHOSEN DISCIPLINE IS AS FOLLOWS:

                INSTRUCTION TYPE 1  INSTRUCTION TYPE 2  INSTRUCTION TYPE 3  INSTRUCTION TYPE 4


COURSE LEVEL 1           15.827              15.832               5.322               0.0
COURSE LEVEL 2           13.453              17.937               8.968               0.0
COURSE LEVEL 3            6.218              12.443               4.132               0.0


THE FACULTY FTE (BY DISCIPLINE, COURSE LEVEL AND FACULTY RANK) = (THE WEEKLY FACULTY CONTACT HOURS
        (BY DISCIPLINE, COURSE LEVEL AND INSTRUCTION TYPE) MULTIPLIED BY THE PERCENTAGE DISTRIBUTION
        (BY DISCIPLINE, COURSE LEVEL, FACULTY RANK AND INSTRUCTION TYPE) (SEE MODULE 3))
        DIVIDED BY THE FACULTY LOAD (BY DISCIPLINE, COURSE LEVEL, FACULTY RANK AND INSTRUCTION TYPE).

THE FACULTY FTE (BY COURSE LEVEL AND FACULTY RANK) FOR THE CHOSEN DISCIPLINE IS AS FOLLOWS:

                FACULTY RANK 1  FACULTY RANK 2  FACULTY RANK 3  FACULTY RANK 4  FACULTY RANK 5


COURSE LEVEL 1          0.308           0.616           0.925           0.616           0.616
COURSE LEVEL 2          1.211           1.211           1.211           0.404           0.616
COURSE LEVEL 3          0.997           1.282           0.570           0.404           0.616
```

Figure 6.7: Samples of the TRACER-TRAINER Output (continued 2 of 2 pages)

CHAPTER SEVEN

USING THE MODEL

7.1 Running the Model

To run RRPM 1.3, it is necessary to operate three programs making three separate passes on the computer. The first program (Part I) calculates the instructional expenses; the second program (Part II) calculates the noninstrutional expenses; and the third program (Part III) produces the output for both Parts I and II. The run sequence necessary for the three programs is shown in Figure 7.1. (See page 54.)

The programs of the RRPM-1 have been written in segments for two reasons: one is to reduce the computer memory requirements, and the other is to enable an institution to run the instructional sector (Part I) independently of the noninstructional sector (Part II). Thus, if an instituiton does not have its equations for estimating the nonacademic expenses or the relevant data necessary to run Part II, then it can at least compute the expenses for the academic sector by using Part I.

Part III generates output for both Part I and Part II. Their content, their levels of aggregation, their use in planning and comments on cautions regarding their use are discussed below:

7.2 Output Generation

The results of the computations by RRPM-1.3 are stored in an output file (see right hand middle position of Figure 7.1). The user's selection of the needed report (s) is identified in report parameters that along with the RRPM-1 Report Generator produces the desired reports.

For the instructional program there are eight different types of reports. Six of these reports can be aggregated at one or all levels of the PCS and more. Similarly, noninstructional programs can be aggregated but only to a subprogram level. These levels of aggregation for each type of report are shown in Figure 7.2 (See 55.) In each case the name of the level of aggregation can be defined externally by the user to correspond to the administrative units in his institution. Two reports that cannot be generated at different levels but only for the entire institution are those on construction costs and student enrollment by level of student and type of instruction.

A sample of each type of report is shown in the Introduction.[1] The type of report, the type of program, and the level of aggregation are each identified by a two digit code. This composite six-digit report code is identified in the title of each report. Its English equivalent is also shown in the title of each report. An example of this correspondence is illustrated in Figure 7.3.

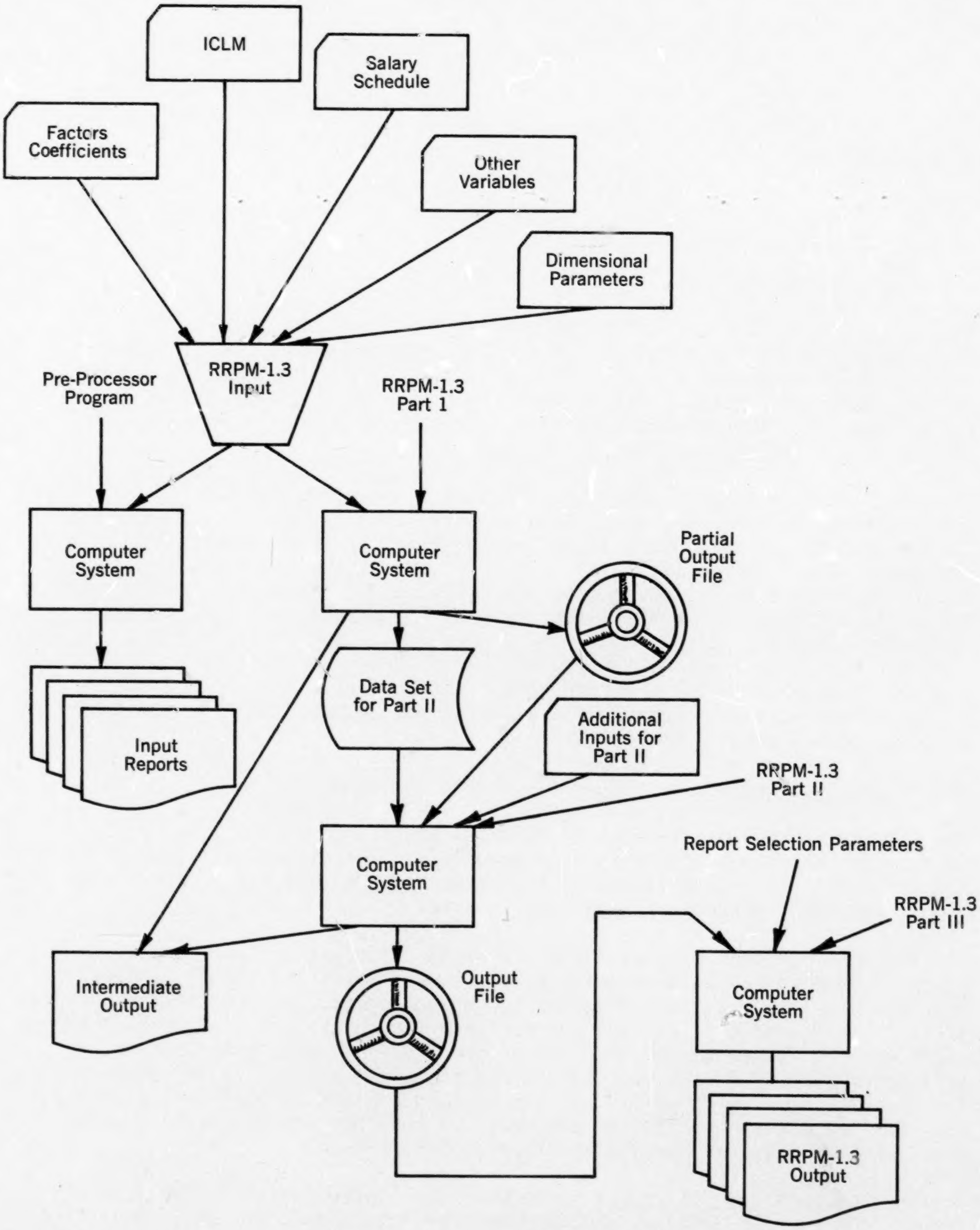


Figure 7.1: RRPM-1.3 System for Reporting

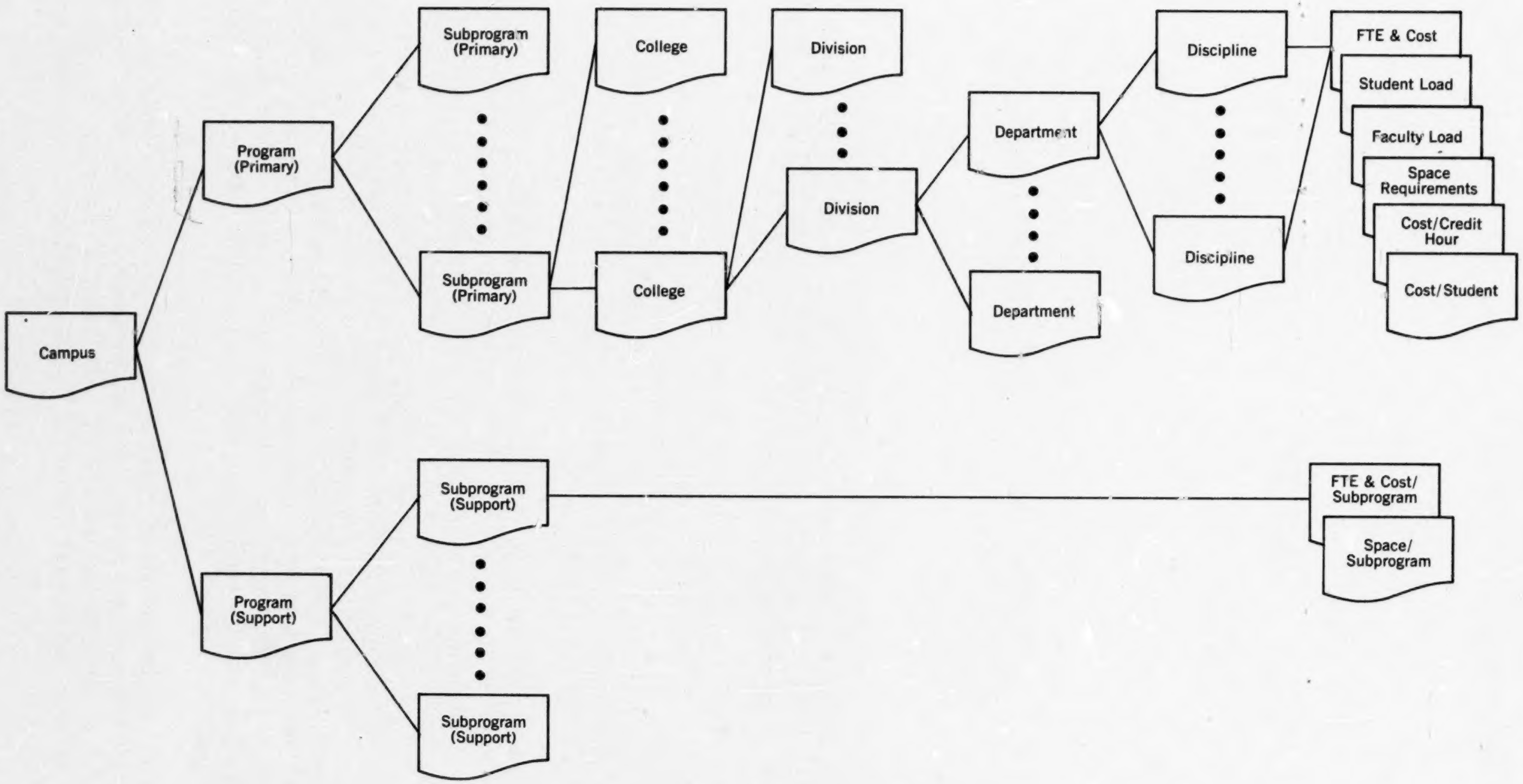


Figure 7.2: Levels of Aggregation of Standard Output from RRPM-1

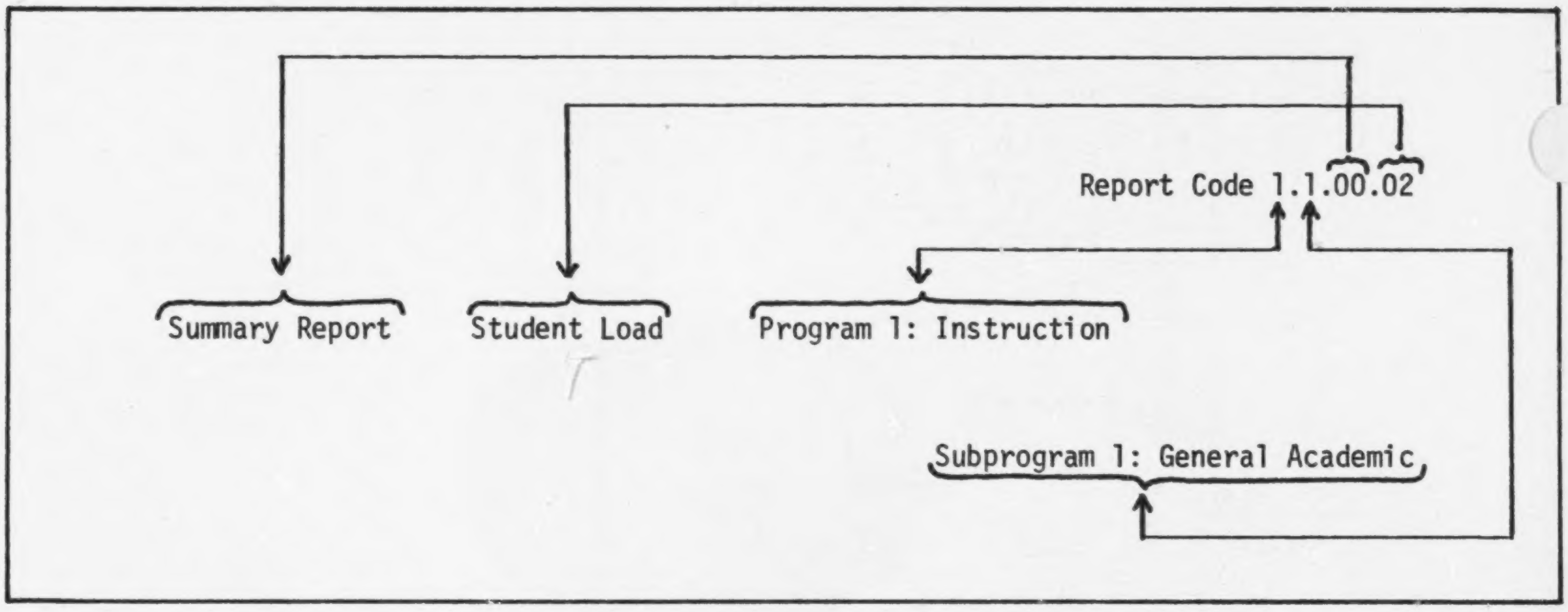


Fig. 7.3: Sample of Report Code and Its Meaning

To generate the desired report and appreciate the versatility of the Report Generator, one must understand the options offered to the user. This can be done by studying the generalized form of the Report Code as shown in Figure 7.4. Also shown are the codes for each subfield.

There are restrictions on the values of codes in some fields when used in combination with codes in other fields. For example, faculty and student loads (Reports 2 & 3) can be calculated only for the instructional program (i.e., X = 1 according to the PCS for the format shown in Figure 7.4). This and other allowable code combinations along with allowable levels of aggregation are shown in Figure 7.5.

The number of reports that can be generated by RRPM-1.3 is very large. If all these were sent to each decision maker, he would most likely exceed his "absorption capacity," making the reports lose much of their value. It is important, therefore, that the reports relevant to each decision maker are identified. If identification is not made by the decision maker, it should be done by the project manager, who must also ensure that the reports are distributed according to a schedule and that the significance of the reports is well understood. Furthermore, the project manager must explore the additional related reports that can be generated from the RRPM output file. The output file has a mass of raw data and a desired report may well be generated with a very small marginal cost. This possibility must be investigated.

In addition to the standard reports in the prediction mode of the RRPM, there is another output mode: the experimental. The experimental mode is achieved by a routine called ENDYR. In it, the data at the end of each year can be changed to ask "what if" type questions. Changes can be made

General form of Report Code = XY.ZZ.NN

Where X = Code of Program (See codes in the PCS, Fig. 4.3)

Y = Code of Subprogram (See codes in the PCS, Fig. 4.3)

ZZ = Code for level of aggregation of report

NN = Code for type of report

Codes for ZZ

00 = Summary

01 . . . . 99 } Discipline Number which is the sequential ordering of the disciplines when the data is read, i.e., if the History Discipline data is read first then the reports of the History Discipline can be generated by using 01 code in this field.

Codes for NN

01 = FTE and Cost

02 = Student Load

03 = Faculty Load

04 = Space Requirement

05 = Construction Costs

06 = Enrollment

07 = Cost per Credit Hour

08 = Cost per Student

Fig. 7.4: RRPM-1.3 Report Code

REPORT TITLE	REPORT CODE	LEVEL OF AGGREGATION
FTE & Cost	XY.ZZ.01	For any valid program (X) & subprogram (Y)
Space Requirements	XY.ZZ.03	
Student Load	1Y.ZZ.02	Only instructional program (X = 1) but any valid subprogram (Y = 1 - 4)
Faculty Load	1Y.ZZ.04	
Construction Costs	00.00.05	Only for total campus, i.e., all levels of subprograms, (XY = 00). Since it is a summary report ZZ = 00.
Enrollments	00.00.06	
Cost per Credit Hour	1Y.ZZ.07	For instructional subprograms only (X = 1) but any valid instructional subprogram (disc. or dept. for cost/credit hour & major for cost/student).
Cost per Student	1Y.ZZ.08	

Figure 7.5: Report Code: Its Structure, Levels of Aggregation References to Sample Reports

in any desired variable or parameter as well as in any coefficient (constant or variable) in an estimation equation. The type of changes available to the user include the following:

1. A percentage change (positive or negative)
2. An absolute change (positive or negative)
3. A replacement of a value
4. Replacement of an entire set of values for a given variable

In addition, an entire new degree program can either be added or deleted. Any one or more of these changes is regarded as one "case" and up to nine cases are allowed in one execution of the system. All changes can be for one year or a series of changes over a number of years, but no more than a total of nine cases of changes can be made in any one run. Additional changes would require separate runs.

The output is entitled "Alternative Policy Implications" and a sample is shown elsewhere.[2]

For changes that involve adding a degree program, the ENDYR assumes that the new program will use the existing disciplines and departments offering courses. If the existing disciplines or departments have to be changed, the base data must be modified, and the modification can be done by using the Partial Pre-Processor III (PPP3).

The functions of the PPP3 and the ENDYR are somewhat overlapping in that both modify data. The main difference is that PPP3 is designed mainly for modifying any data on the input file before the RRPM is run while ENDYR modifies some data for one or more years and enables the direct running of the Report Generator for each of these changed data sets.

The discussion of analytical reports (in the experimental or predictive mode) concludes the identification of the different types of reports generated by RRPM-1. The other reports were discussed earlier: the pre-processor under 5.3, intermediate output under 6.5.1, and the TRACER-TRAINER under 6.5.2. These reports are summarized diagrammatically in Figure 7.6. (See page 60.)

7.3 RRPM-1 In Planning Cycle

Whether in the predictive mode or the experimental mode, RRPM-1 provides information that the decision-maker can use in evaluating the consequences of alternative resource decisions. The flow of the process is depicted[3] in Figure 7.7. Faced with the responsibility of decision-making, the manager is simultaneously concerned with the societal environment and his evaluation of the performance of the institution (boxes 1, 2, and 3). Assessment of these and other factors lead to establishment of goals and objectives as well as priorities and policies

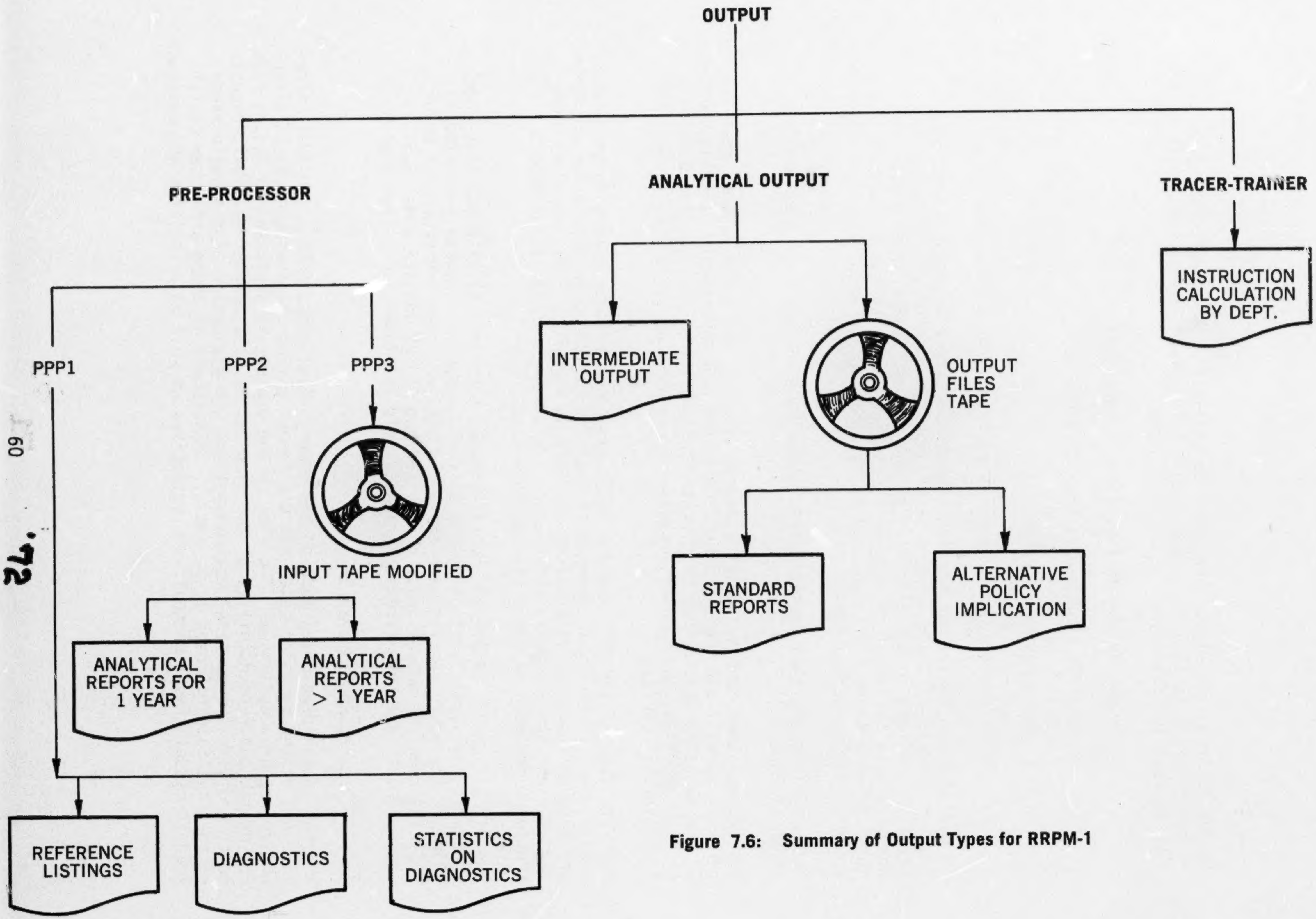


Figure 7.6: Summary of Output Types for RRPM-1

for their attainment (boxes 4 and 5). The manager now makes a trial decision (exit of box 6) and uses RRPM-1 (box 7) to calculate the resource consequences of that decision based on institutional data (box 8). The results are displayed in analytical reports (symbol 9).

After reviewing the consequences of his trail decision, the manager may wish to change the values selected for some of the planning variables and re-calculate the resource consequences. The cycle (boxes 6, 7, and 9) continues until the manager is satisfied. The long term resource decisions are then translated into budgets and other resource allocations, (exit of box 10) resulting in operations of the institution (box 11). After a period of time passes for the operations, say an academic year, the analytical reports from RRPM-1 and the performance of the operations are again evaluated (box 3) and the planning cycle repeats itself.

The concepts described above begin with evaluation and goal setting. However, the cyclical nature of the planning process permits an actual beginning at almost any point in the cycle. It is recognized that goal setting and performance evaluation are an important part of the total planning process, yet the measurement of instructional effectiveness is very difficult. Therefore, it is anticipated that formal performance goals and evaluation of results may be quite subjective in early phases of total planning implementation.

7.4 Cautions Concerning Output

When using the output from RRPM-1, the user must exercise caution. For example:

1. The output of RRPM-1 is dependent on the relevance and accuracy of the many coefficients used in the model and the many structural relationships concerning support costs that the institution must supply.

2. The costing output from RRPM-1 is designed for analytical use within an institution. It is not designed for interinstitutional cost exchange, a subject of a separate project under NCHEMS. Furthermore, the costs calculated in RRPM-1.3 are average costs, not marginal costs.

3. The output from RRPM-1 must not be used in a mechanistic way. R. Low, Vice-President of Administration in a pilot institution, expresses this concern as follows:

   > The argument has been made and will continue to be made that, if we have MIS and RRPM and the like, we will tend to make educational decisions strictly in efficiency terms--decisions by technocrats or programmed people--and the learning environment will suffer. Education will be dehumanized. That could happen; the danger is there. Information in the wrong hands can be used to produce undesirable and unwanted results. In wise hands, however, it can only help to make education more responsive to society's needs.[4]

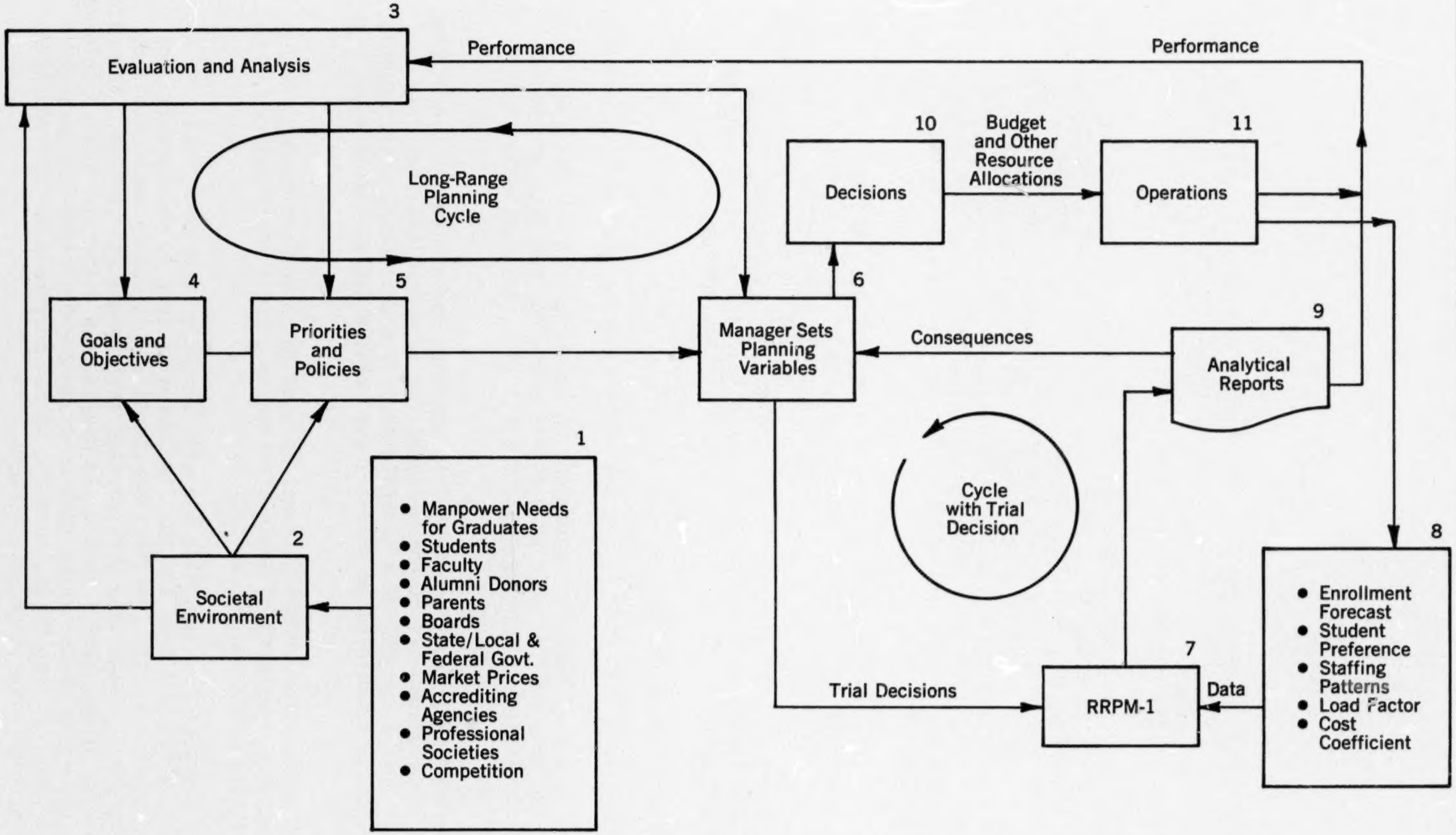


FIGURE 7.7: RRPM In Planning Cycle

CHAPTER EIGHT

ORIENTATION AND TRAINING

8.1 Introduction

The validation of the model and all the preceding stages are often not the most difficult. They involve hardware and software problems that can sooner or later be resolved. The most difficult set of problems may be people problems: those of getting management to know enough about the model and have enough trust in it to make them want to use it. This requires careful orientation and purposeful training.

Rosove makes a distinction between orientation and training.

> Orientation...is a learning situation in which the users of the system are introduced to it. Training, by contrast, is the acquisition of basic skills by personnel, the development of satisfactory personnel, man-machine and man-computer program interactions, and in general, overall improvement in system performance under all varieties of potential real-life situation.[1]

Orientation and training in the context of the above definitions are both requirements for a successful implementation of RRPM-1.3. Both, however, require that attention be given to the following steps: the judicious selection of the audience; the careful design of content for relevancy and meaning; appropriate strategies for presentation; and a logical sequence and schedule for presentations. Consideration for each of these steps will be discussed below.

8.2 The Audience

For training on the RRPM-1 the audience must be only those who are closely related with running the model, but for orientation all levels of personnel concerned with the model should be involved. This would include top and middle management, the operations researchers, the statisticians and the institutional researchers, the faculty, the programmers, and the computer analysts. Some topics of orientation should be specifically addressed to specific levels of personnel attending the meeting; however, there should be occasions when the developers and the users meet. It is on such occasions that the "gap" between their knowledge and attitudes can be bridged, and they can see and appreciate each other's viewpoint.

Orientation can do much to eliminate or reduce resistance to RRPM-1.[2] But there may always be some resisters and skeptics. For handling them, Caffrey has the following advice:

> "Those who conduct MIS training programs should not waste time worrying about the hard-core resisters and doubters. We must take advantage of the curiosity and interest of those...administrators who are now willing to encourage or at least permit the development of better management information systems. If we maintain good lighthouses, others will be guided to port....The best salesmen are satisfied customers.[3]

8.3 Content

There is a core of content to which all personnel concerned with RRPM-1.3 should be exposed. This includes concepts of planning, modeling, MIS (Management Information Systems), PPBS (Planning, Programming, Budgeting Systems), simulation, optimization and systems implementation.[4] Some topics are continually changing and should be topics for progress reports, especially such topics as models in higher education and projects of NCHEMS.

Some topics should be addressed only to specific groups. Thus, the technical personnel must be told about instructional goals, objectives, and policies; planning and its role in institutional decision making; and the technical details of RRPM-1. Likewise, management must be specifically addressed on information systems, the institutional data base, and management science techniques without creating a "jargon barrier" and without going into technical details. The content for management's orientation should be aimed at its typical fears of simulation models and especially RRPM-1. It must be repeatedly emphasized that RRPM-1 merely provides additional relevant information designed to aid the decision maker. It will not replace the manager and his judgment. The manager must still identify the variables that may be changed and choose from sets of consequences generated by RRPM and associated with a set of alternatives.

Another fear of the manager using RRPM-1 is that its unit cost calculations will be misused by control agencies.[5] But if data can be used to the detriment of an institution, could it not also be used (and to a greater extent!) for its benefit? Could the results of RRPM not be used to strengthen one's bargaining position, answer the critics, point out the areas of relative high and low costs, and justify one's needs? These considerations must be carefully examined.

8.4 Strategies of Presentation

Many strategies may be used in the orientation and training programs for RRPM-1.3. These include lectures, seminars, discussion groups, games, the TRACER-TRAINER, and finally, publications. Each will be discussed in turn.

8.4.1 Lectures, Seminars, and Discussion Groups

Lectures and seminars can be used very effectively for purposes of orientation. They can be organized by in-house personnel or outside personnel. The latter may be expensive, but outside seminars provide contacts and an exposure to how things are done elsewhere. In-house programs have the advantage of being given by those knowledgeable about the institution and tailored more to the interest of the audience. Furthermore, they provide an opportunity to bridge the gap between developers and users.

Where interaction is necessary, it is better to have small discussions. These may start in the president's cabinet meeting and continue later as brain-storming sessions. Such meetings are productive in evaluating the model. This was done effectively in one pilot institution. Here is part of the minutes of a final session:

> "Would you use RRPM in the course of your job?" Answer "Yes." Of course, there were modifying and explanatory statements, ...but we had come a long way from "What is it?" and "It frightens me" to "Yes."[6]

8.4.2 Games

Games are used extensively in schools of business as well as by industry as a medium for training decision makers.[7] Some games are designed especially for the educational environment.[8] One of these was adapted and used by one pilot institution.[9] It was evaluated as very useful by its participants because it provided insights into interrelated variables and trade-offs. Furthermore, it "involved" them in planning.

8.4.3 TRACER-TRAINER

The TRACER-TRAINER has been mentioned earlier in the context of debugging the test results. It was actually designed as a training aid and addressed to the manager. All of the output is in English with every abbreviation, acronym, and term carefully defined. It displays all of the steps in the computations of the expenses for any discipline and identifies the inputs only as they are needed.

The motivation of this routine arose at one pilot institution that was training the head of the department of physical education. A numerical example with data for the biology department was used. The trainee found that many of the coefficients and factors used were not realistic for him. He wanted the computations for his department, using his coefficients. The TRACER-TRAINER was designed for such a need. It is best used by the manager working with an analyst who is knowledgeable about the RRPM-1 computer program.

One pilot institution is currently implementing the TRACER-TRAINER on a terminal. The program is in small logical modules. The user can study any one module and can go back or forward to any other module. One module is designed for training a user to use the terminal.

8.4.4 Publications

Publications could be generated either internally or externally. The advantage of the former is that RRPM-1.3 can be discussed in the context of the problems of the institution, its state laws, and the policies of its governing body. Such publications can be profitably supplemented by external publications.[10]

8.5 Sequence and Schedule

Once the audience is identified, the content of presentation determined, the strategy of presentation selected, it is then necessary to schedule the training. This can be done formally by using an Orientation and Training Table such as the one shown in Figure 8.1. (See page 67.) Some cells in the matrix are not appropriate and are therefore blocked out. Others need dates that are a function of the willingness and convenience of personnel involved and a logical sequence of the presentations.

The orientation should be scheduled soon after the decision to implement or fears will surface and rumors will circulate. Training on RRPM output can start early using sample RRPM output, but it is perhaps better to wait until institutional output is generated. (This approach is shown in the diagram in Figure 2.1, Page 3.) The advantage is that institutional output is more realistic, and furthermore it may be different from the sample output.

The activity of orientation and training should continue as long as RRPM is used in planning. Furthermore, this activity should be responsive to the many changes that will occur. For example, there will be changes in computer technology with more sophisticated on-line equipment, terminals, graphic displays, and light-pens. Their relevance to planning must be continuously examined. Also, personnel, both users and developers, will change. Finally, models and modeling techniques will change. Among them will be successors to RRPM-1 and related models. These must be continuously evaluated for relevance to the institution.

TOPIC \ AUDIENCE	TOP MANAGEMENT	MIDDLE MANAGEMENT	STAFF (OR IR, ETC.)	EDP PERSONNEL	FACULTY	BOARD
Modeling in Higher Education						
NCHEMS Projects						
RRPM & Planning						
RRPM Output						
RRPM Input & Logic						
ICLM						
Exercises on RRPM						☒
TRACER-TRAINER						☒
Data Base				☒		☒

Fig. 8.1. Orientation and Training Table

CHAPTER NINE

SUMMARY & CONCLUSIONS

This chapter is a series of observations, some of which have been stated before but are being restated for emphasis.

1. All computer programs and documentation needed for implementing RRPM in an institution of higher education are available to all interested institutions. Yet, there is much that must be done before RRPM can be effectively employed: the understanding of the model; its modification, and especially the determination of estimation equations; the calculation of factors and coefficients; and the validation of the model for the institution. The task requires a substantial amount of time, money, and hard work.

2. After validation, an institution may be wise to use RRPM in parallel with its past techniques of planning until the limitations and strengths of RRPM are fully understood.

3. Once RRPM has been implemented, one must constantly be on guard against its possible misuse. Perhaps the best safeguard against misuse is a sound understanding of the model, its assumptions, and its relationships.

4. This document is concerned with the initial implementation of RRPM-1. To use RRPM-1, or any similiar model on a continual basis, it is necessary to update and maintain it. The need for maintenance and modification arises from changes in the goals and policies of the institution, changes in management personnel and its needs, changes in computing capabilities, and finally technological developments in modeling.

   If the modifications necessary to the model are major ones, all the steps of the initial implementation of RRPM-1 will have to be repeated, the relevant relationships identified coefficients recomputed, new data collected, and the revised model validated.

5. To maintain the continuous process that RRPM-1 should represent, it is important that some continuity between those who initially implement RRPM-1 and those who maintain it is important. Continuity among the systems personnel associated with RRPM-1 is also very desirable.

6. One final set of comments. It must be remembered that RRPM is concerned only with planning variables that are quantifiable. The nonquantifiable variables of planning are equally, if not more, important. They include educational issues and outputs that we have not yet learned to identify, much less measure.

RRPM is an aid to planning. It is not an alternative to planning but just one piece of a comprehensive planning process. It must not be used out of the context of its assumptions and its structural limitations. Its output should not be considered sacrosanct just because it is produced on a computer. Its numbers must not be used for a mechanistic allocation of resources but must be used only to aid the manager with information relevant to the planning process. The judgment and knowledge of the manager are not replaced but is aided by RRPM-1.

APPENDIX

Sample Computations

The purpose of this appendix is to facilitate a better understanding of all types of computations performed in the RRPM-1 model. This is done by dividing the computations into small logical segments and performing the computations in a series of exercises. In order to keep the arithmetic easy, the institutional environment and its data are assumed to be simple, and hence not necessarily representative of the real world. This enables an emphasis on the concepts rather than the mathematics of solution.

The sequence of the exercises follows the logic of the RRPM-1 model as shown in Figure 4.1. (page 9). We start with the ICLM and go through all the computations necessary for determining the total cost to the institution, given a set of policy variables. Also computed are the cost per student in a field of study and the cost per credit hour in any one discipline or department.

Each exercise follows a standard format: the problem is stated; the relevant data is listed; the logic of the problem is represented schematically (these are often extracts of the logic flow of RRPM shown in Figure 4.1 (page 9 with reduced dimensions); the problem is solved numerically; and finally, this is followed by comments whenever appropriate.

For reference and review, the symbols used are as follows:

FTE = Full-Time Equivalent

ICLM = Induced Course Load Matrix

SCH = Student Credit Hours

WSH = Weekly Student Contact Hours

xxx
↳ = Policy Variable xxx

(xxxx) = Endogenous Variable xxxx

The exercises that follow are the calculations of the following:

Exercise 1 - SCH for each instructional department (using ICLM in credit hours)

2 - SCH for each instructional department (using average total credit hours per major as planning variable)

3 - WSH for each instructional department

4 - Faculty FTE for each instructional department

5 - Salaries for each instructional department

6 - Support Costs for each instructional department

7 - Total expenses for each instructional department

8 - Total Instructional Costs

9 - Total Institutional Costs

10 - Cost per Student Credit Hour in a department

11 - Cost per student in a field of study

Exercise 1

1.1 Problem: Determine the SCH by department for lower division students

1.2 Data: Given the ICLM in average Credit Hours per division major in Figure 1.1

	Major #1	Major #2	Major #3
Dept. A	3	6	3
B	3	3	7.5
C	9	6	4.5
Total Credit Hours per Major	15	15	15

Figure 1.1

and enrollments (Major #1) $M_1 = 100$

$M_2 = 60$

$M_3 = 80$

for lower division (no other division students assumed in these exercises for purposes of keeping the problem simple).

1.3 Schematic Logic:

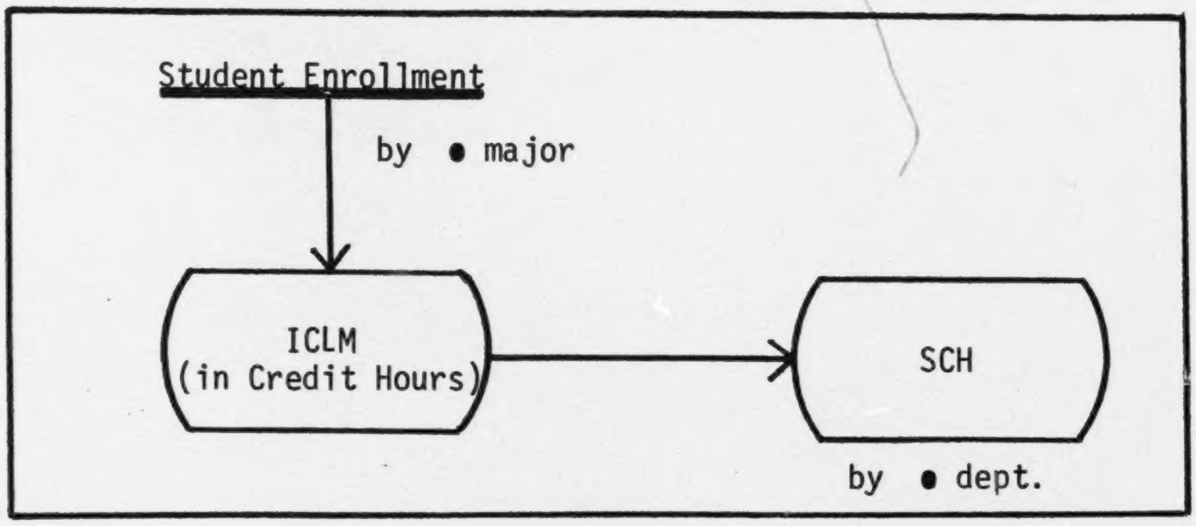


Figure 1.2

1.4 Solution:

$$\text{SCH for dept.}_i = \sum^{\text{all } i} \begin{array}{l}\text{credit hours taken in dept.}_i \text{ by 1 major}_j \\ \text{x enrollment in major}_j\end{array}$$

$$\begin{aligned}\text{SCH for dept. A} &= 3 \times M_1 + 6 \times M_2 + 3 \times M_3 \\ &= 3 \times 100 + 6 \times 60 + 3 \times 80 \\ &= 300 + 360 + 240 \\ &= 900\end{aligned}$$

Using the same procedure of calculations for the other departments, we have the following:

	M_1	M_2	M_3	Total SCH for each dept.
Dept. A	3 x 100 = 300	6 x 60 = 360	3 x 80 = 240	900
Dept. B	3 x 100 = 300	3 x 60 = 180	7.5 x 80 = 600	1080
Dept. C	9 x 100 = 900	6 x 60 = 360	4.5 x 80 = 360	1620

Figure 1.3

The above result can also be achieved by using matrix multiplication shown in Figure 1.4. The matrix approach is convenient, but not essential and will not be used in future exercises.

$$\begin{bmatrix} 3 & 6 & 3 \\ 3 & 3 & 7.5 \\ 9 & 6 & 4.5 \end{bmatrix} \times \begin{bmatrix} 100 \\ 60 \\ 80 \end{bmatrix} = \begin{bmatrix} 900 \\ 1080 \\ 1620 \end{bmatrix}$$

Figure 1.4

1.5 Comments:

The ICLM in credit hour units can be converted to a proportional share of the credit hour load. This requires that the values in credit hours (cells in Figure 1.1) be divided by the total credit hour load by major (totals in Figure 1.1).

This is done in Figure 1.5 giving the results in Figure 1.6.

3/15	6/15	3/15
3/15	3/15	7.5/15
9/15	6/15	4.5/15

Figure 1.5

.2	.4	.2
.2	.2	.5
.6	.4	.3

Figure 1.6

The calculations done above were for the lower division student only. This will not be restated in all the following exercises in order to avoid repetition. It is true throughout all these exercises.

The ICLM discussed above is using departments as the administrative unit offering courses. The computations would be similar for disciplines.

The ICLM representation in Figure 1.6 or that in Figure 1.1 are both acceptable in the RRPM-1.3. However, if the representation of Figure 1.6 is used, an additional variable of average credit hour load per student must be provided. This is demonstrated in Exercise 2.

Exercise 2

2.1 Problem: Calculate SCH per department using the average total credit hours per major as a planning variable.

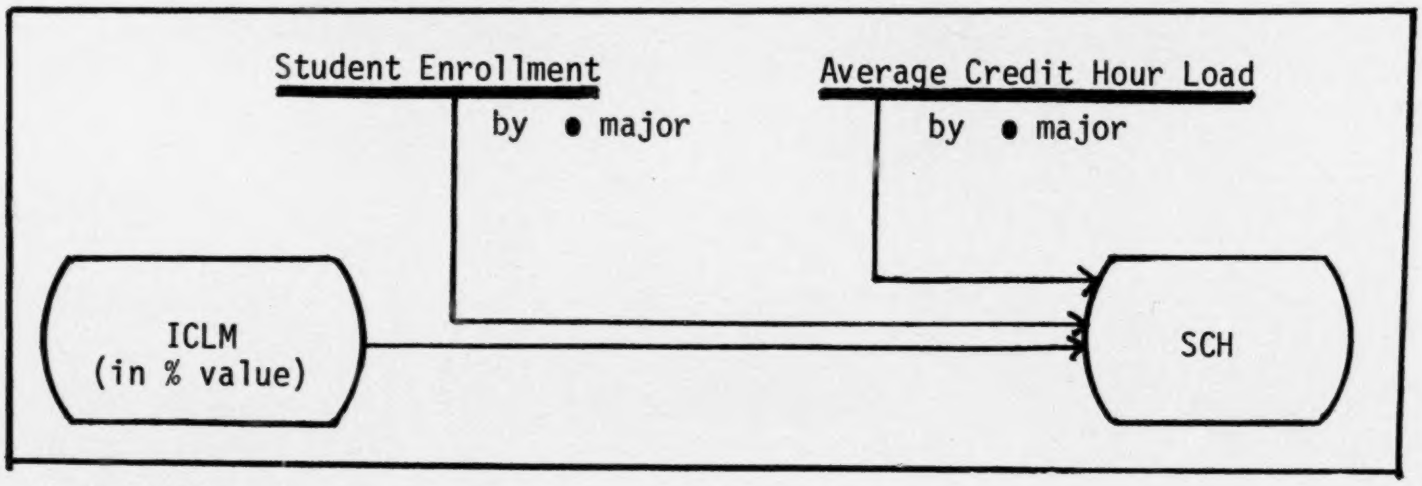
2.2 Data: Average credit hour for each major = 15 (same as in Exercise 1 to demonstrate a point. Each could vary, of course.)

ICLM

.2	.4	.2
.2	.2	.5
.6	.4	.3

Student enrollment by major = same as in Exercise 1.

2.3 Logic Representation:



2.4 Solution:

$$\text{SCH by dept.}_i = \sum^{\text{all } i} \left[\text{ICLM coef.}(i,j) \ (\text{in \% value}) \times \text{average credit hour load/major}_j \times \text{student enrollment by major}_j \right]$$

$$\begin{bmatrix} .2 \times 15 \times 100 & .4 \times 15 \times 60 & .2 \times 15 \times 80 \\ .2 \times 15 \times 100 & .2 \times 15 \times 60 & .5 \times 15 \times 80 \\ .6 \times 15 \times 100 & .4 \times 15 \times 60 & .3 \times 15 \times 80 \end{bmatrix} \quad \begin{bmatrix} 300 & 360 & 240 \\ 300 & 180 & 600 \\ 900 & 360 & 360 \end{bmatrix} \quad \begin{bmatrix} 900 \\ 1080 \\ 1620 \end{bmatrix}$$

2.5 Comments:

The results for Exercise 1 and 2 are identical. The difference in the two exercises is in the data input. In Exercise 1 the ICLM is in credit hours, and in Exercise 2 it is in percent of credit hour load, requiring another variable: the average credit hour load per major. This could be a useful planning variable for some institutions and is the approach shown in Figure 4.1.

The SCH for each department is necessary to determine faculty load, but the faculty load is directly related to the WSH by department and varies with type of instruction. We need to convert the SCH by department into WSH by instruction type in each department. This is the subject of the next exercise.

Exercise 3

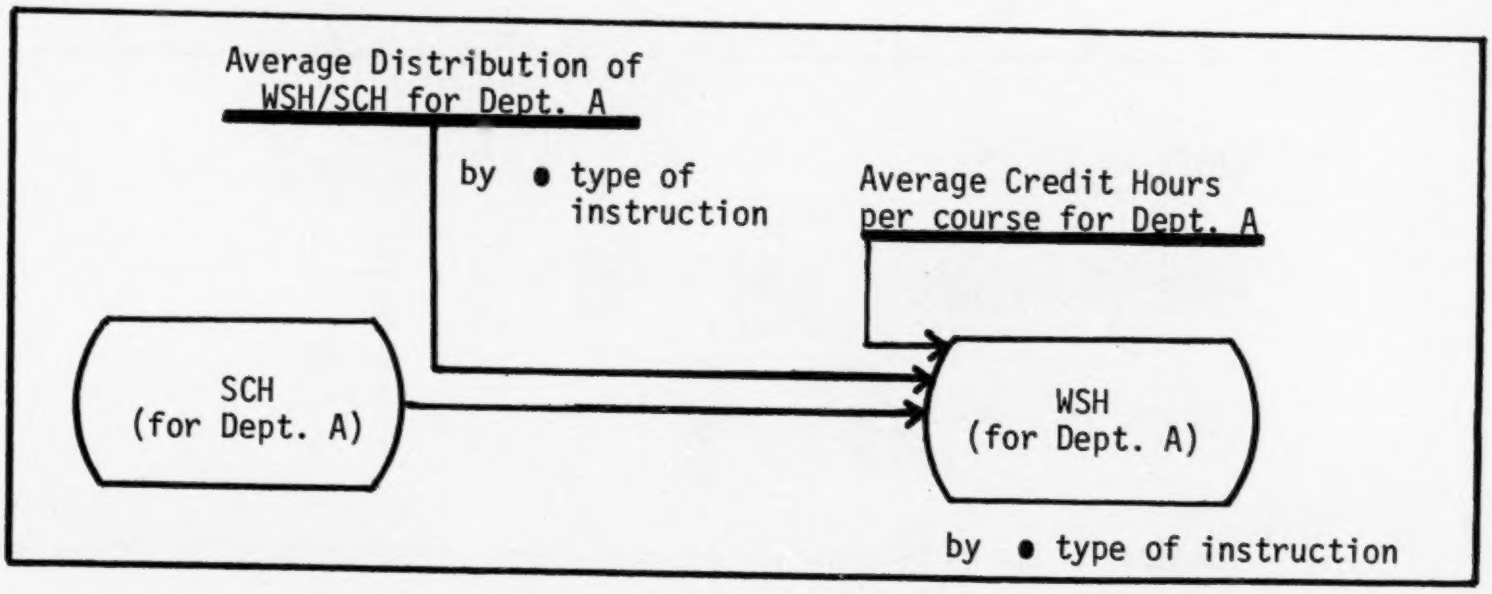
3.1 Problem: Calculate the WSH for department A by type on instruction

3.2 Data:

1. SCH for department A = 900 credit hours
2. Distribution of 6 contact hours generated by a 4 credit hour course is as follows:

Lecture = 3
Lab. = 2
Recitation = 1

3.3 Diagram of Logic Flow:


Average Distribution of WSH/SCH for Dept. A
by • type of instruction
Average Credit Hours per course for Dept. A
SCH (for Dept. A)
WSH (for Dept. A)
by • type of instruction

3.4 Solution: Consider the type of instruction: lecture

Ratio of average WSH/SCH for department = 3/4

Using the same ratio for all the SCH generated by department we have

WSH for lecture = SCH for department x ratio of WSH/SCH for lecture

= 900 x 3/4 = 675

The same method of computations should be used for other types of instruction. This can best be done in a tabular form where each column is numbered and its source is identified (at the bottom of the heading of the column).

The solution for all types of instruction appears below:

Type of Instruction (K)	① Weekly Contact Hours WSH(k) (given)	② Credit Hours for Course (given)	③ Ratio WSH(k)/SCH ③=①/②	④ SCH for Dept. (given)	⑤ WSH by Instructional Type = SCH for Dept. x WSH/SCH ⑤=④x③
Lecture	3	4	3/4	900	3/4 x 900 = 675
Lab	2		2/4		2/4 x 900 = 450
Recitation	1		1/4		1/4 x 900 = 225
TOTAL	6	4	1.5	900	1350

3.4 Check

$$\left.\begin{array}{l} \dfrac{\text{Total WSH for dept.}}{\text{Total SCH for dept.}} = \dfrac{\Sigma \textcircled{5}}{\Sigma \textcircled{4}} = \dfrac{1350}{900} = 1.5 \\[2ex] \dfrac{\text{Average WSH for course}}{\text{Average SCH for course}} = \dfrac{\Sigma \textcircled{1}}{\Sigma \textcircled{2}} = \dfrac{6}{4} = 1.5 \end{array}\right\} \text{OK}$$

3.5 Comments: The determination of the weekly contact hours by instruction type enables the calculation of faculty FTE using faculty work load and average section size for each instruction type as a policy input.

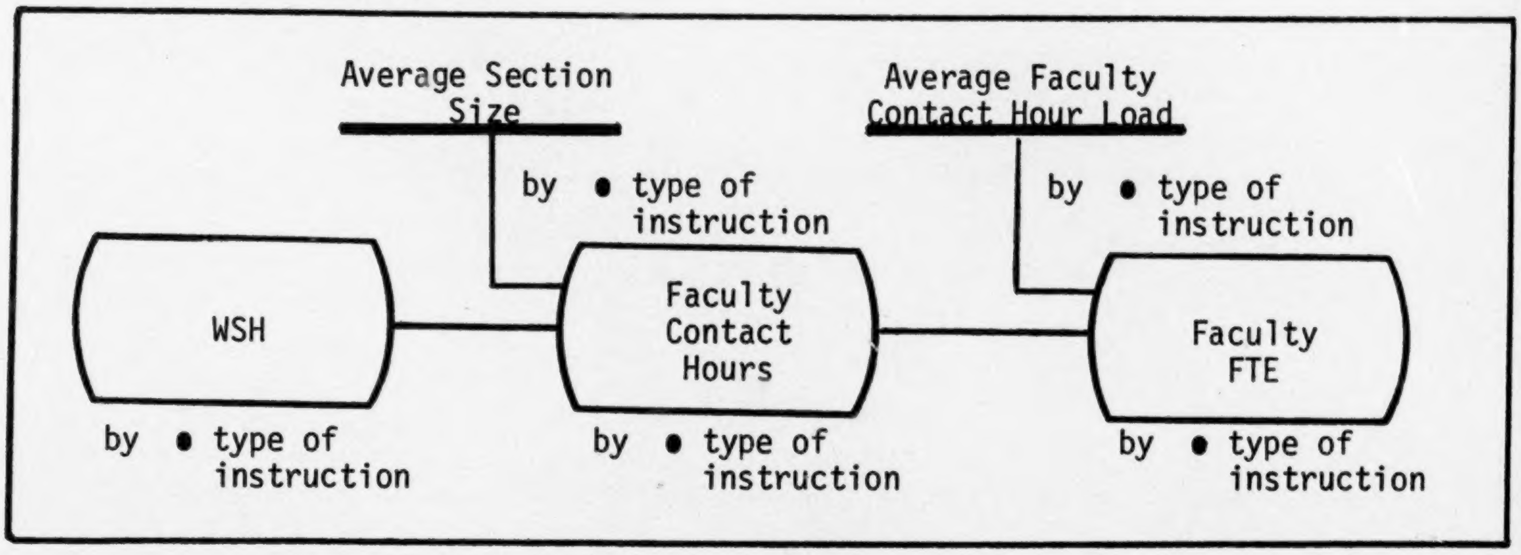
Exercise 4

4.1 Problem: Calculation of faculty FTE for department A.

4.2 Data: Given the WSH by type of instruction for department A as calculated in Exercise 3. Further assume the following policy variables:

	Average Section Size	Average Faculty Load
Lecture	25	9
Lab	15	15
Recitation	9	25

4.3 Diagram of Logic Flow:



4.4 Solution:

	① WSH (from problem #3)	② Average Section Size (given)	③ Faculty Contact Hours ③= ①/②	④ Average Faculty Load (given)	⑤ Faculty FTE ⑤= ③/④
Lecture	675	25	27	9	3.0
Lab	450	15	30	15	2.0
Recitation	225	9	25	25	1.0
				Faculty FTE =	6.0

4.5 Comments: In this exercise, we implicitly assume that class contact hours = faculty contact hours. For multiple instructors teaching the same course, the input data must be adjusted appropriately for section size or teaching load.

Having calculated the faculty FTE, we can now calculate the faculty salaries. This is done in the next exercise.

Exercise 5

5.1 Problem: Calculate instructional salaries for department A.

5.2 Data: Faculty rank mix:

Full Professor	1
Assoc. Professor	2
Asst. Professor	3

Faculty salary schedule: (average salary per FTE)
Full Professor = $18,000
Assoc. Professor = $14,000
Asst. Professor = $10,000

Staff/Faculty = 1/3

Staff salary schedule = $5,000

5.3 Diagram of Logic:

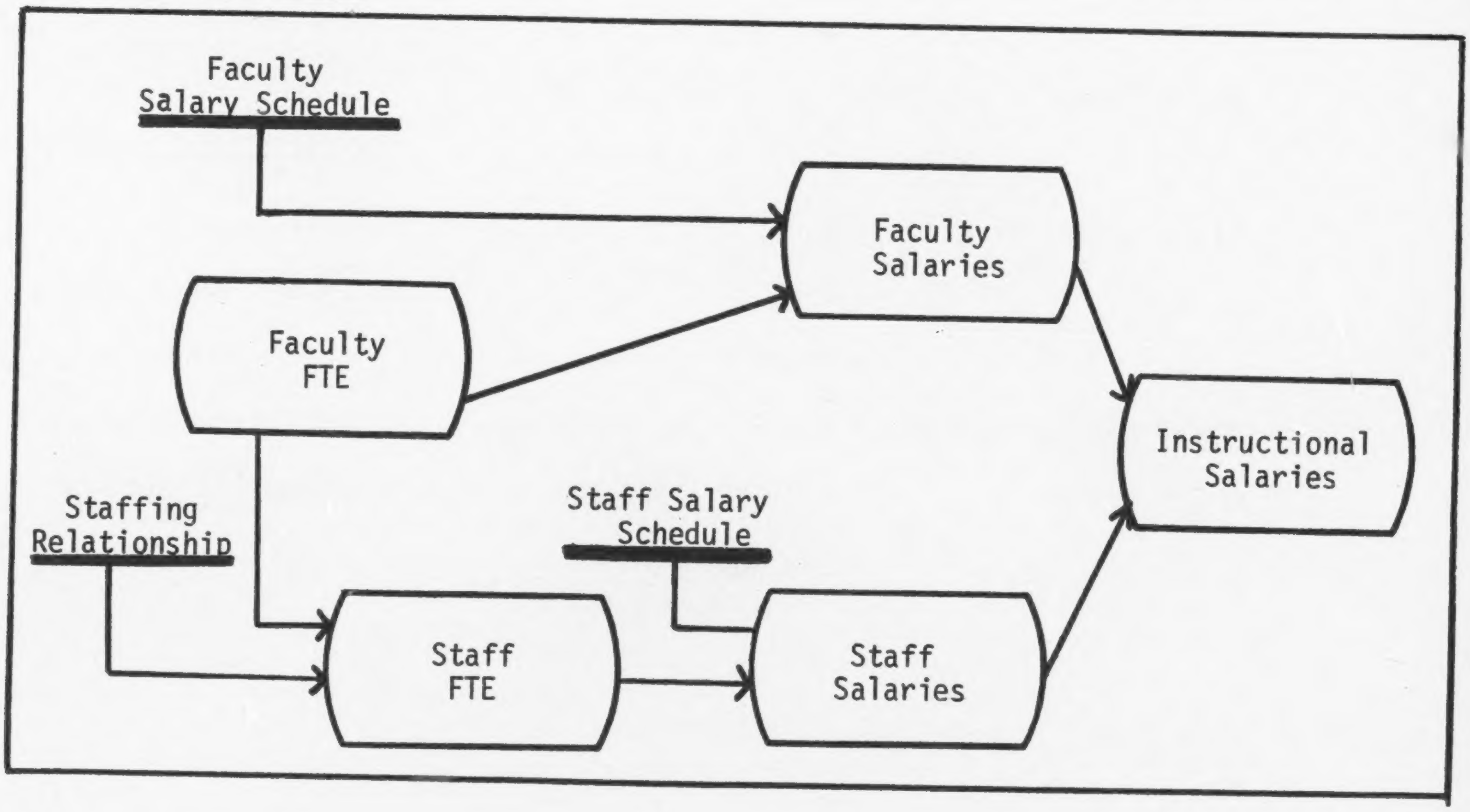


Figure 5.1

5.4 Solution:

Faculty by rank(i) = Total Faculty FTE x ratio of rank i to Total

∴Full Professor FTE = 6 x 1/6 = 1 FTE

Assoc. Professor FTE = 6 x 2/6 = 2 FTE

Asst. Professor FTE = 6 x 3/6 = 3 FTE

Faculty Salary = Salary schedule for FTE by rank x number of FTE by rank

∴Salary for Full Professor = 18,000 x 1 = $18,000

Assoc. Professor = 14,000 x 2 = $28,000

Asst. Professor = 10,000 x 3 = $30,000

Total Faculty Salary Expenses $76,000 ———— ①

No. of staff = Staff/faculty x Faculty FTE

= 1/3 x 6 = 2 FTE ———— ②

Staff Salary Expenses = Staff salary schedule x Staff FTE

= $5,000 x 2 ———— using ② and input data

= $10,000 ———— ③

Total Salary Expenses = Faculty Salary Expenses + Staff Salary Expenses

= $76,000 + $10,000 ———— using ① and ③

= $86,000 ———— ④

∴ means "therefore."

Exercise 6

6.1 Problem: Calculate supply expenses for instructional department A

6.2 Data: The supply expenses for department A has the following relationship:

$$= a + b_1 \times \text{Faculty FTE} + b_2 \times \text{Staff FTE} + b_3 \times \text{SCH}$$

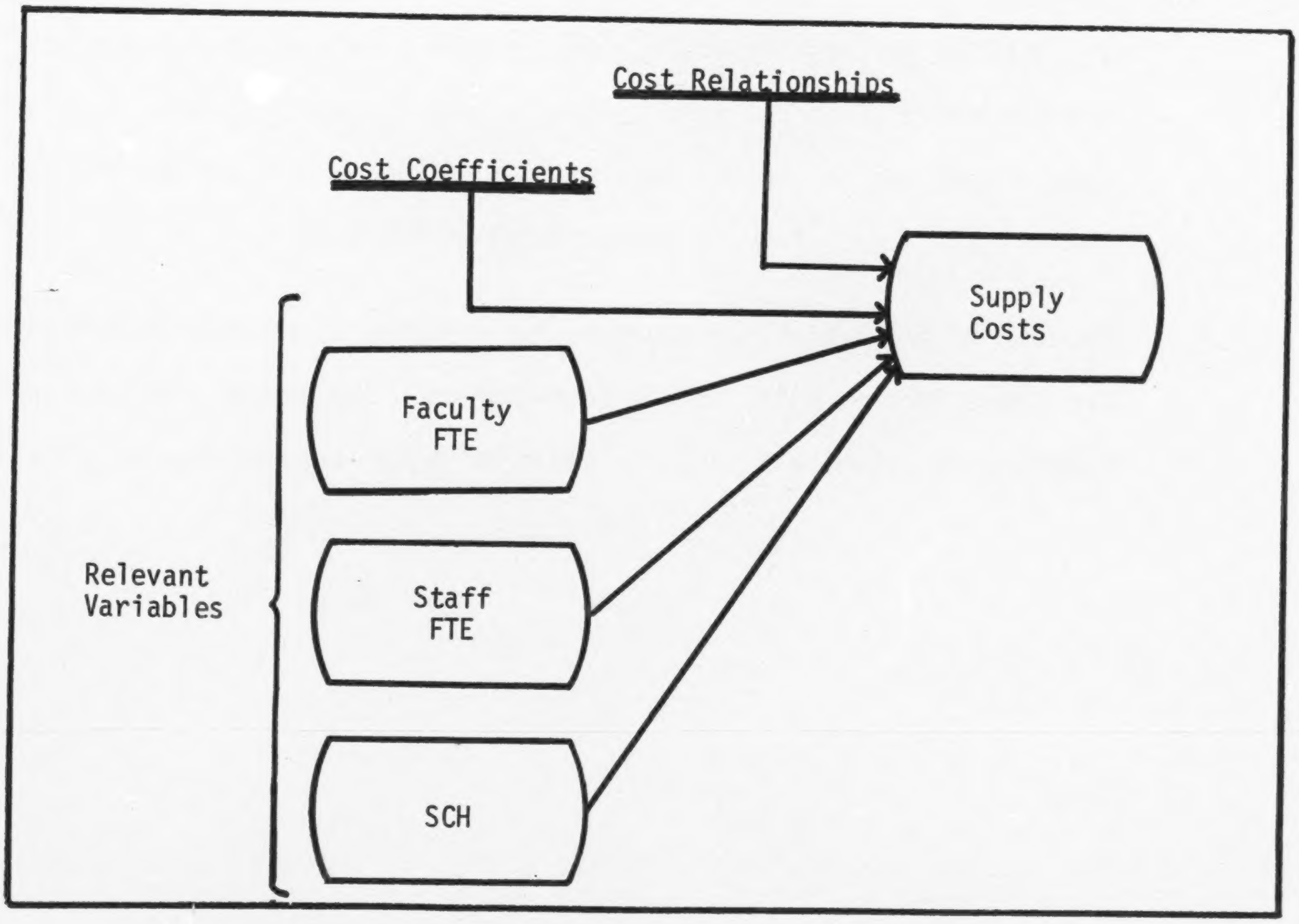
The cost coefficients a = \$2,500 (i.e., fixed cost, irrespective of any other variable)

$b_1 = 100$

$b_2 = 300$

$b_3 = .2$

6.3 Logic Diagram:



6.4 Solution: Relevant variables from previous computations are endogenous (variables calculated in model)

Faculty FTE = 6 (Exercise 4)
Staff FTE = 2 (Exercise 5)
SCH = 900 (Exercise 1, Figure 1.3/1.4)

Supply Support Costs for department A

$$\begin{aligned} &= a + b_1 \times \text{Faculty FTE} + b_2 \times \text{Staff FTE} + b_3 \times \text{SCH} \\ &= 2500 + 100 \times 6 + 300 \times 2 + .2 \times 900 \\ &= 2500 + 600 + 600 + 180 \\ &= 3880 \end{aligned}$$

6.5 Comments: The estimation equation used in this problem is perhaps the most complex of those typically used in RRPM-1 because it includes a constant coefficient and three variable coefficients. In many institutions either the "a" coefficient is zero or one or more of the "b" coefficients are zero. This is demonstrated in Exercise 7.

The form of the estimation equation for supplies is similar to that which could have been used for travel or equipment. The general flow for all nonsalary instructional costs is shown in Figure 6.1(see page 86.)

Exercise 7

7.1 Problem: Determine total instructional expenses for Department A

7.2 Data: Travel Expense = $a_1 + b_1 \times$ Faculty FTE

where $a_1 = 5,120$

$b_1 = 500$

Equipment Expense = a_2 where $a_2 = \$1,000$

7.3 Logic: See Figure 6.1 for general generic flow.

7.4 Solution: Travel Cost = a + b x Faculty FTE

= 5,120 + 500 x 6 (Exercise 4)

= 5,120 + 3,000

= \$8,120 = \$ 8,120

Equipment Expenses (given data) = \$ 1,000

Supply Expenses (from Exercise 6) = \$ 3,880

Total Support Cost for Department A = \$13,000

Instructional Salaries for Department A (from Exercise 5 ④) = \$86,000

Total Instructional Expenses = \$99,000

7.5 Comments: Thus far we have calculated instructional costs for one department: Department A. The same procedures can be used for determining expenses for any discipline or department.

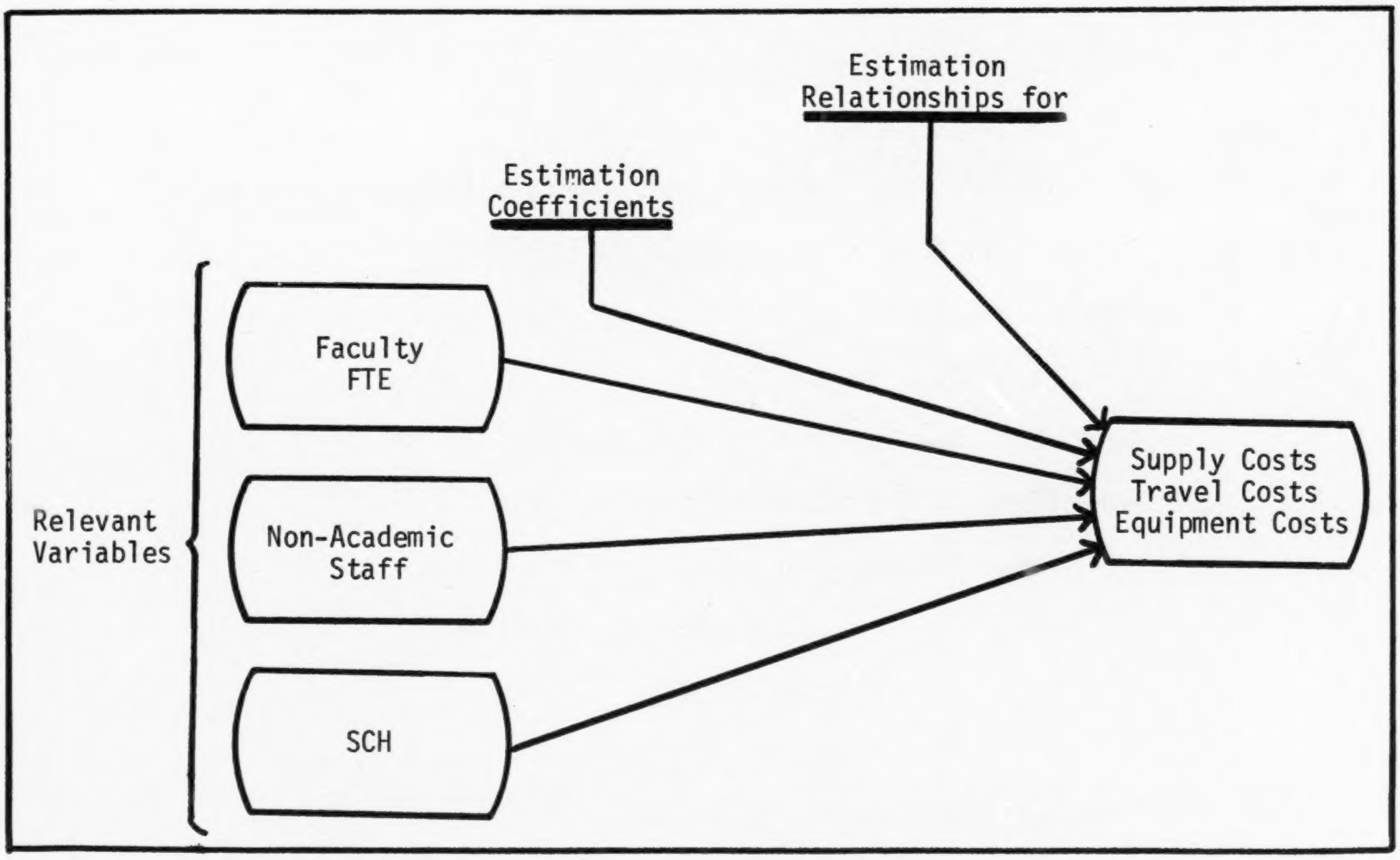


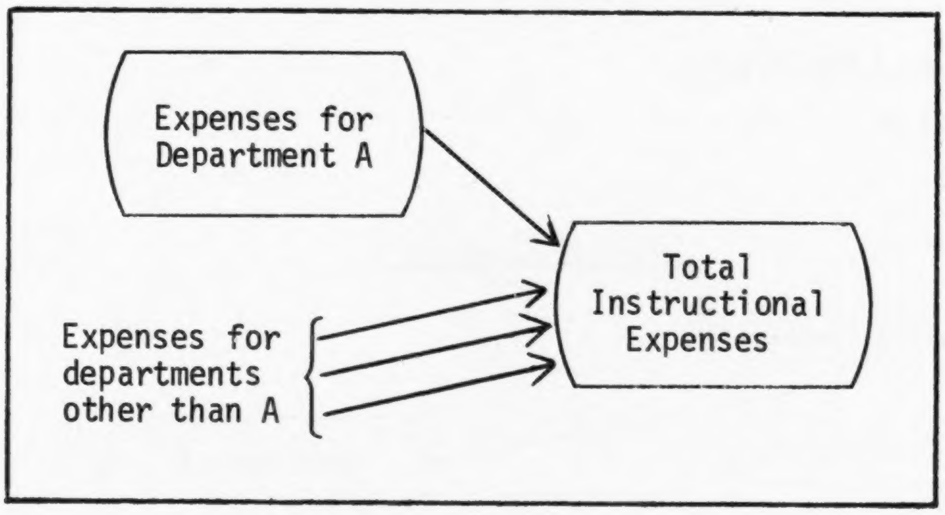
Figure 6.1: NonSalary Instruction Costs

Exercise 8

8.1 Problem: Calculate total instructional costs for institution

8.2 Data: The costs of all departments were calculated in the same manner as that of Department A in Exercises 1-7. The cost of all departments other than Department A = $1,362,148

8.3 Logic Flow:


Expenses for Department A
Total Instructional Expenses
Expenses for departments other than A

8.4 Solution:

Expenses for Department A (from Exercise 7) =$ 99,000

Expenses of other departments (given in data) = 1,362,148

$1,461,148

8.5 Comments: Having calculated instructional expenses, we need to calculate noninstructional support costs to determine total institutional expenses.

Exercise 9

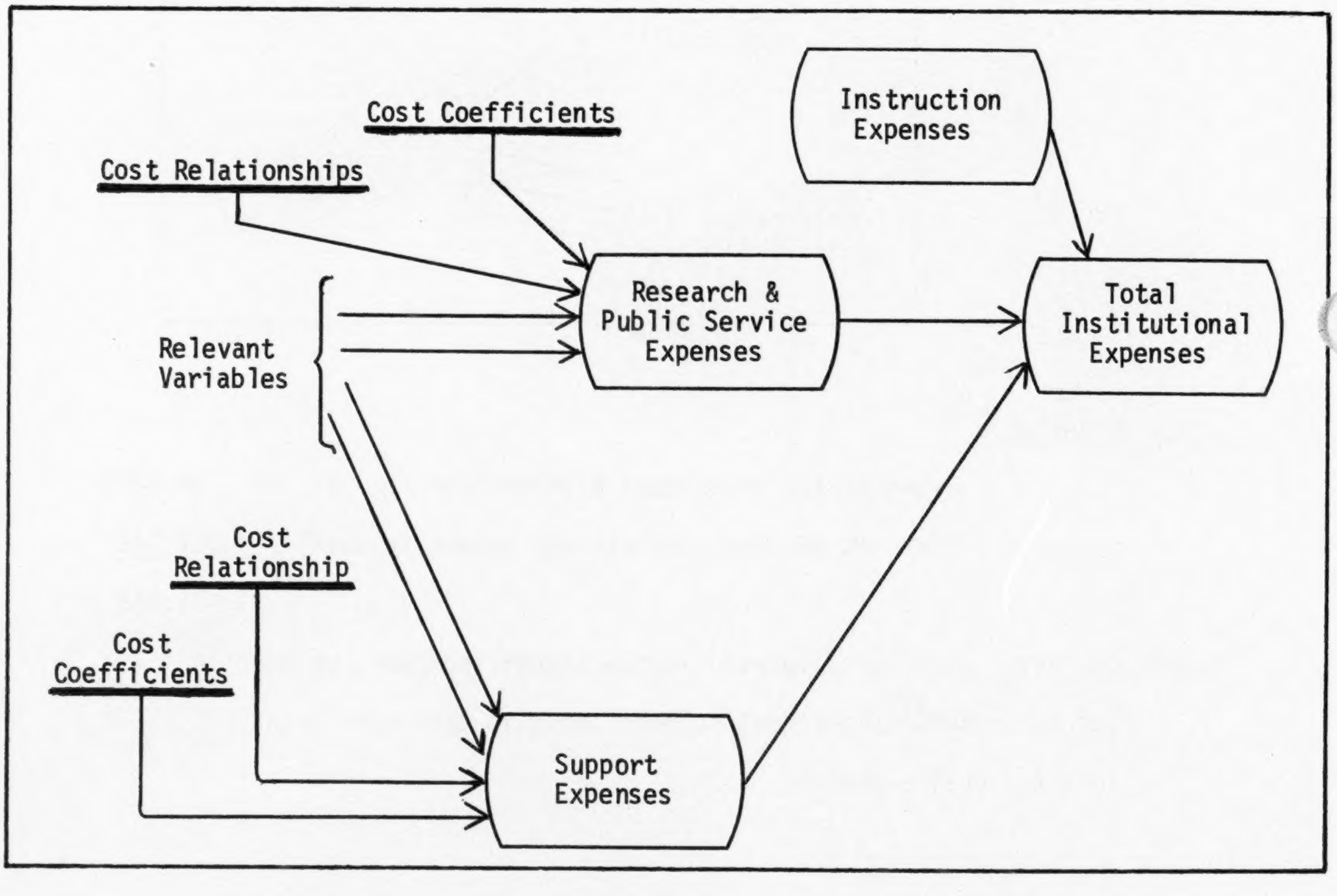
9.1 Problem: Calculate total institutional expenses

9.2 Data: Noninstructional Support Expenses = $632,000

Research & Public Service Expenses = $516,000

These are calculated by using estimation equations similar to those used in Exercises 6 & 7.

9.3 Flow Diagram:



9.4 Solution: Instruction Expenses (from Exercise 8) = $1,461,148

Noninstructional Support Expenses = $ 632,000

Research & Public Service Expenses = $ 516,000

$2,609,148

Exercise 10

10.1 Problem: Calculate instructional cost per credit hour for Department A

10.2 Data: Assume two semesters in one academic year

10.3 Flow Diagram:

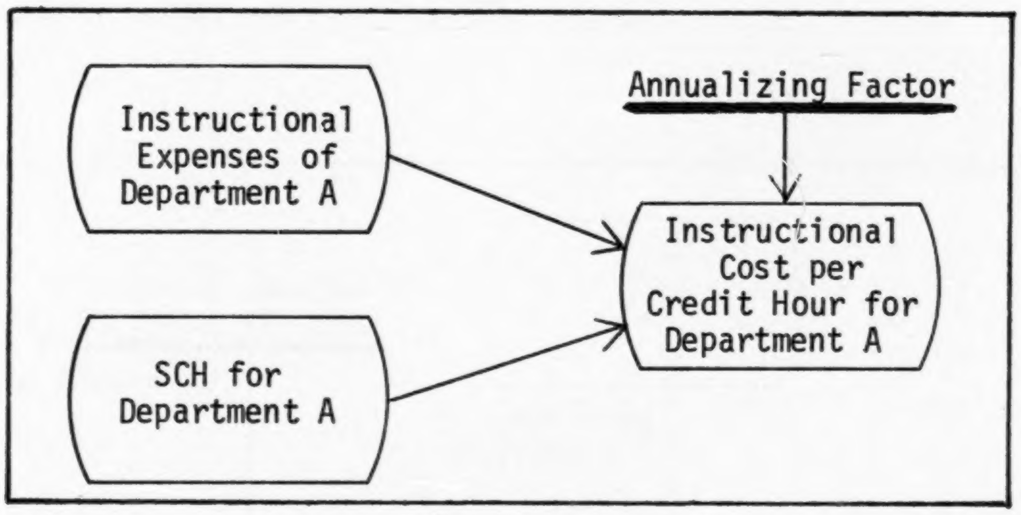

Instructional Expenses of Department A
SCH for Department A
Annualizing Factor
Instructional Cost per Credit Hour for Department A

Figure 10.3

10.4 Solution: From Exercise 7 we have Instructional Costs
for Department A = \$99,000
From Exercise 1 we have SCH for Department A
for one semester = 900
Using an annualizing factor = 2, SCH for
Department A for year = 1,800
Cost per credit hour = Instructional Costs/SCH

$$= \frac{\$99,000}{1,800}$$

= \$55 for Department A

Exercise 11

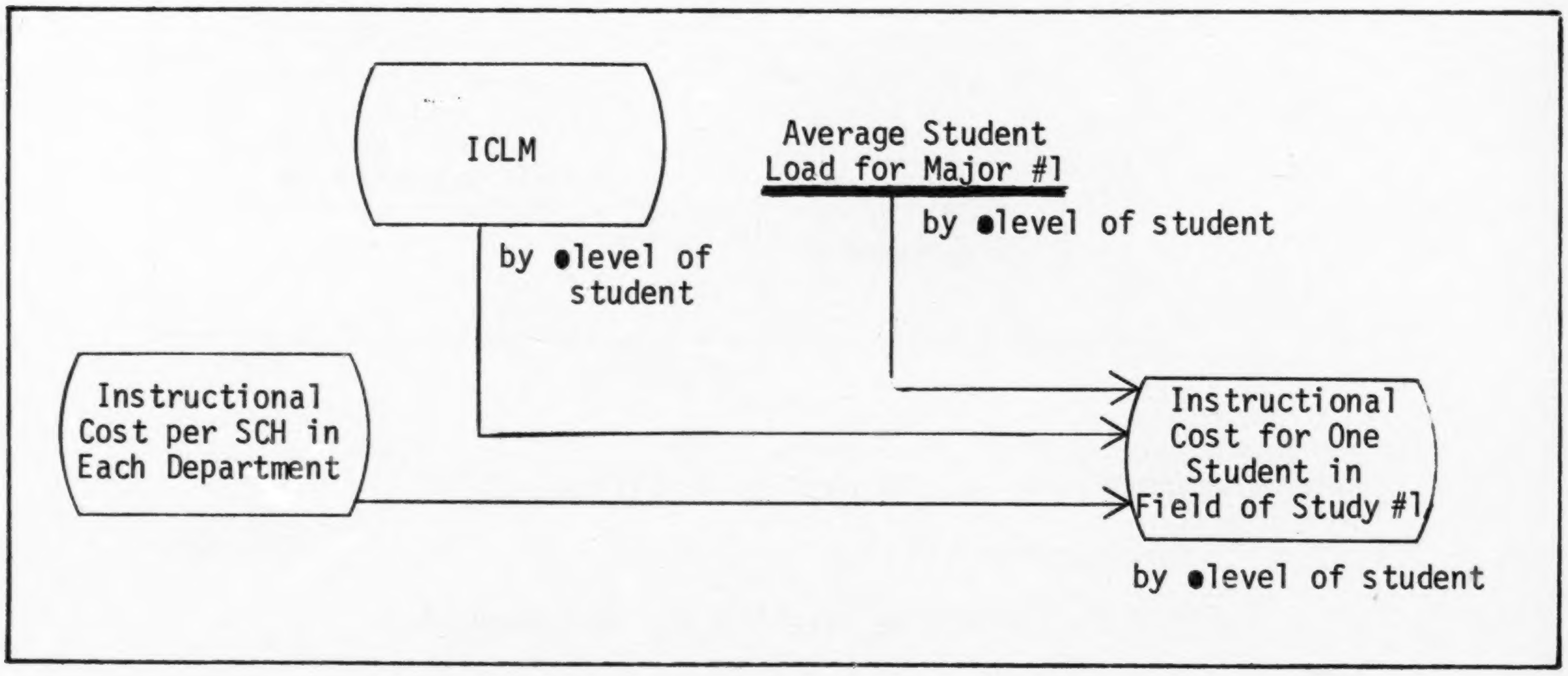
11.1 Problem: Calculate instructional cost of a lower division major in field of study #1 for one term of study.

11.2 Data: Cost per SCH for Department B = $60 per term of study

C = $40 per term of study

Assume average student load for major 1/term = 16 credit hours

11.3 Flow Logic:


ICLM
by •level of student
Average Student Load for Major #1
by •level of student
Instructional Cost per SCH in Each Department
Instructional Cost for One Student in Field of Study #1
by •level of student

The ICLM to be used is with proportional load (Exercise 2) since the average student load per major is a planning variable.

The ICLM calculated in Exercise 2 which is for a lower division student, is as follows.

.2	.4	.2
.2	.2	.5
.6	.4	.3

11.4 Solution:

$$\text{The cost per student major}_j = \sum^{\text{all } i} \left[\text{ICLM coeff.}(i,j) \times \begin{array}{l}\text{Average student}\\ \text{load per credit}\\ \text{hour per term}\\ \text{for major}_j\end{array} \times \begin{array}{l}\text{Average cost}\\ \text{per credit}\\ \text{hour in each}\\ \text{dept.}_i\end{array} \right]$$

	① ICLM Coefficient for Major #1 (Calculated in Ex. 2)	② Average Student Load for Major #1 (Given Data)	③ Average Cost per Credit Hour in each dept. (Exercise 10 & Given Data)	④ Cost per Dept. ④=①x②x③
Dept. A	.2	16	55	176
Dept. B	.2	16	60	192
Dept. C	.6	16	40	384

Cost of Student in Major #1 for one term = $752

11.5 Comments: The above cost figure was calculated for only lower division students since they are the only type assumed in these exercises. The computations for other levels of students would of course be similar to those for the lower division shown above.

The cost figures calculated in Exercises 10 & 11 are for instruction only. The total cost can be calculated for any major and discipline/SCH by allocating the noninstructional costs to the instructional units by some allocating procedures. Thereafter the computational steps are similar to those used for calculating instructional costs/SCH.

The one important set of computations of RRPM-1.3 not included in this appendix concerns the space subroutines. It provides only gross estimates of facilities requirements and incremental costs of construction. It is not a substitute for formal facilities planning. However, it is conceived that RRPM-1.3 could be used by some institutions along with a capital planning model. Twenty-two space types were, therefore, retained in RRPM-1.3.

The space routine was not tested by the pilot institutions but is included in the RRPM-1.3 system and is discussed further in the Programmer's Manual and Input Specifications.

ANNOTATED BIBLIOGRAPHY

This annotated bibliography was prepared by members of the RRPM Task Force and other persons associated with the development of RRPM. It is an attempt to guide the reader through the literature related to the RRPM and enable him to select according to his interest, needs, and background.

SELECTED ANNOTATED BIBLIOGRAPHY

Ackoff, Russell L. A Concept of Corporate Planning. New York: John Wiley & Sons, 1970.

Ackoff's concise and systematic treatment of the planning process, with general emphasis on the use of planning models, is the best available conceptual source for potential users of RRPM. Although the central objective of profit-making in the American corporate planning does not directly apply to nonprofit institutions of higher education, Ackoff's concept is easily translatable into the college and university setting. The emphasis on the organizational requirements for effective planning is especially important.

For a more generalized treatment of the planning process, see Melville C. Branch, Planning: Aspects and Applications. New York: John Wiley & Sons, 1966. An excellent outline and critique of the rational planning theory may be found in Martin Meyerson and Edward C. Banfield, Politics, Planning, and the Public Interest. Chicago: The Free Press, 1955.

T. R. Mason, University of Colorado

Andrew, Gary M., and Moir, Ronald E. Information-Decision Systems in Education. Ithaca, Ill.: F. T. Peacock Publishers, Inc., 1970.

Programmed versus Nonprogrammed Decisions; Systems and Subsytems; Models and Modeling; Kinds of Variables; Simulation; Goals, Policies, and Operations; EDP and MIS; PERT and CPM. If you need an uninspired but solid grounding in what these concepts are, then this is an excellent book. The description of the purpose and operation of PERT and CPM is especially good.

R. J. Low, Portland State University

Bogue, E. G. An Inquiry Into the Relationship Between Instructional Cost Patterns and Assumptions Influencing Analysis of Basic Data in Unit Cost Studies. Paper presented at the AIR Meeting in Denver, Colo., 1971.

This paper examines the statistical results of applying differing assumptions to the computation of instructional unit costs at Memphis State University based on a study conducted in the Fall of 1970. Wide variations in unit costs were shown:

(1) When instructional salaries were allocated to courses on the basis of faculty report of effort as compared to allocation based on course credit values; and

(2) When instructional salaries were allocated to instructional level on the basis of course number as compared to student level.

Four methods of allocation based on these variables are shown graphically, and the implications of these findings for program management are discussed. The selection of allocation criteria can have an important influence on cost patterns and can have a profound impact on higher education as states conduct such studies and use them as a basis for the development of a state-wide formula for allocation of funds. This paper shows that careful attention needs to be given to the goals of different types of institutions in establishing budget formulas and planning models.

A. Harris, University of California
at Los Angeles

Casasco, Juan A. "Corporate Planning Models for University Management Report 4." Washington, D. C.: Eric Clearinghouse on Higher Education, The George Washington University, October 1970.

____. "Planning Techniques for University Management" American Council on Education with the Eric Clearinghouse on Higher Education, 1970.

These two reports, funded by various agencies, represent on the whole studies of the literature against conceptual bases developed by the author. The first treats the broad problem of management of universities and may provide insights of where RRPM might fit in. The second describes and compares operational models having a special bearing on academic facilities for those having a special interest in this area. An additional five of the operational models described are much more comprehensive. Six other models in the developmental stage are described.

D. L. Trautman, S.U.N.Y. at Stony Brook

Churchman, C. W. The Systems Approach. New York: Dell Publishing Co., Inc., 1968, 243 p.

A very readable book by one of the forefathers of Operations Research and Management Science. The book examines "what the 'systems approach' means. It does so not from the point of view of 'selling' the idea, but rather by examining its validity in the climate of a debate."

The debate is between the advocates of efficiency and the advocates of the use of science on one side with the advocates of the use of human values (freedom, dignity and privacy) and the anti-planners on the other side. The debate is illustrated with many homely examples from every day life.

This book is recommended not only to the technical project manager of an RRPM-1 project but also to the non-technical manager in higher education.

K. M. Hussain, New Mexico State University

CODASYL Data Base Task Group, Report of. New York: Association for Computing Machinery, (referred to henceforth as ACM), October 1969.

This report, the first major collaborative effort toward definition of a generalized data base system, proposes a Data Description Language and a Data Manipulation Language. The former is used to describe, independent of a host programming language, the characteristics and organization of a data base. The Data Manipulation Language, proposed as an extension of existing high level programming languages, deals with all requests from user programs for data, utilizing generalized call statements with defined parameters. Although a Data Base Management System as such is not defined in the report, the DDL and DML are seen as major constituents of such a system.

M. Roberts, Stanford University

Data Base Management System Requirements. Tulsa, Okla: W. D. Stevens, Skelly Oil Company. Prepared by the Joint GUIDE and SHARE Data Base Requirements Group, November 1970.

This report is a statement of the current position of GUIDE and SHARE in attempting to define long range requirements for data base management systems. There is substantial similarity between this document and the CODASYL Data Base Task Group report, although the terminology differs in some respects. The CODASYL Data Description Language is here called a Data Base Descriptive Language; the Data Manipulation Language is a Data Base Command Language. This report is more operationally oriented than the CODASYL report, reflecting the operational concerns of the SHARE/GUIDE user group membership. Both should be read for a broader picture of both requirements and alternative solutions to a data base design.

M. Roberts, Stanford University

Emshoff, J. R., and Sisson, R. L. Design and Use of Computer Simulation Models. New York: The MacMillan Company, 1970, 301 p.

This is a survey text on simulation for a management scientist who is relatively unfamiliar with the field and for the student with a background in basic calculus and statistics. While Chapters 3 and 4 discuss general problems and approaches in Simulation Methodology and Model Building and Use, the orientation is towards the simulation of specific industrial processes rather than large-scale educational systems. The text is inappropriate for administrators who lack a mathematical-technical background and for experienced practitioners of simulation.

P. J. Czajkowski, University of Illinois

Emery, J. C. "Management Information System" in J. S. Aronofsky Progress in Operations Research. New York: John Wiley & Sons, Inc., Vol. III, 1969, pp. 489-524.

Much of this article is devoted to the concepts of planning and is a glimpse of the author's excellent book, Organizational Planning and Control Systems. Emery also discusses planning and systems in the framework of a management information system, a subject of interest to all RRPM-1 implementers. Recommended for the serious reader.

K. M. Hussain, New Mexico State University

Farmer, James. An Approach to Planning & Management Systems Implementation. Los Angeles: California State College, 1971.

This paper describes the reasons for development and implementation of planning management systems in institutions of higher education, relates the history and significance of the Western Interstate Commission for Higher Education (WICHE) Planning and Management System (PMS) program, and compares two approaches to implementation. It is suggested that a gradual or evolutionary approach to implementation is preferable to a large-scale design and implementation in order to gain the benefit of training and early experience before committing to full-scale implementation. Six beginning steps are suggested: 1) Executive training; 2) Development of an analytical capability; 3) Implementation of program cost accounting; 4) Application of an RRPM; 5) Application of a student flow model; 6) Selection and implementation of a scheduling model. The author assumes (implicitly, I think) that the institution has been appropriately "organized" structurally and has a basic data base. Achieving these prerequisites is a non-trivial matter and has not been discussed. Otherwise Farmer's article is worth reading. It is appropriate for an RRPM implementer because it discusses RRPM in the context of other related activities.

K. M. Hussain, New Mexico State University
D. S. Lawson, California State College
at Humboldt

_____. Why Planning, Programming, Budgeting Systems for Higher Education? Boulder, Colo.: WICHE, 1970, 24 p.

A balanced and realistic description of the concepts of program budgeting as applied to higher education. A brief and highly readable non-technical pamphlet that describes the conditions in society which have lead to pressures to impose program budgeting in higher education; an operational definition and example of "P-P-B-S"; and an experienced assessment of the limitations of program budgeting. The phamphlet indicates that the lack of clearly measurable units of output limits the value of program budgeting in education as well as in other social institutions. It is extremely important that everyone implementing RRPM understands this limitation and develops an approach that appropriately relates RRPM with the "outputs" of a given institution.

B. M. Cohn, University of Utah

"Feature Analysis of Generalized Data Base Management Systems," CODASYL Systems Committee Technical Report, May 1971, (Available from ACM.)

"Survey of Generalized Data Base Management Systems," prepared by the Conference of Data Systems Languages (CODASYL). (Available from ACM.)

These two reports (the latter is somewhat out of date) provide an insight into specific implementations of systems intended to provide generalized support of data base requirements. The scope and availability of generalized systems are changing rapidly and the prospective user should consult potential vendors for accurate and current information.

M. Roberts, Stanford University

Federsen, A. P. Uses of and Problems Associated with Planning Models: Some Experiences. Los Angeles, Calif.: Office of the Chancellor of the California State Colleges, 1971.

Focuses on some of the pragmatic problems of management understanding and use of planning models. Mentions a variety of planning models in higher education but concentrates on three: (1) RRPM, (2) the Induced Course Load Matrix, and (3) the Facilities Analysis Model being developed by the California Coordinating Council for Higher Education.

D. Lawson, California State College at
Humboldt

Geoffrion, A. M., Dyer, J. S., and Feinberg, A. "An Interactive Approach for Multi-Criterion Optimization with an Application to the Operation of an Academic Department." Working Paper No. 176, Western Management Science Institute, UCLA, July 1971, 26 p.

Professor Geoffrion, et al., have formulated a departmental resource allocation decision problem which they solve by mathematical programming. The local gradient to the criterion function is assessed by the department chairman on successive iterations by considering pairwise tradeoffs.

G. B. Weathersby, University of California
at Berkeley

Gulko, Warren W. Program Classification Structure--Preliminary Edition for Review. Boulder, Colo.: NCHEMS at WICHE, June 1970, 100 p.

Dr. Gulko presents the preliminary version of the NCHEMS program classification structure which will be used as a basis of costing techniques, data arrays, and standard reports. This version has been extensively reviewed and a first edition will be issued shortly.

G. B. Weathersby, University of California
at Berkeley

Henle, R. J., S. J. Systems for Measuring and Reporting the Resources and Activities of Colleges and Universities. St. Louis, Missouri: St. Louis University, June 1965.

The "Henle Report" funded in the "early days" by NSF was the forerunner of much of the initial WICHE thinking. It provides a comprehensive taxonomy of academic activities and resources and a genuine help to those initiating or revising their data bases. It is useful as a reference.

D. L. Trautman, S.U.N.Y. at Stony Brook

Jewett, F. I., et al. The Feasibility of Analytical Models for Academic Planning: A Preliminary Analysis of Seven Quarters of Observation of the "Induced Course Load Matrix." Los Angeles, Calif.: Office of the Chancellor of the California State Colleges, September 1970.

This is one of the few articles on a subject that is crucial to models such as RRPM-1. It is well organized. The text is addressed to the manager and the appendix has the technical details of interest to the analyst. There is also an excellent bibliography on related material.

The approach used in calculating an ICLM using historical data is that of calculating the mean. There are other approaches that may be more appropriate including weighted means.

K. M. Hussain, New Mexico State University

Johnson, Charles B., and Katzenmeyer, William G., eds. Management Information Systems in Higher Education: The State of the Art. Durham, N. C.: Duke University Press, 1969.

The Johnson and Katzenmeyer volume is a collection of papers that basically predict the potential of management information systems in higher education as of the summer of 1969. This was a critically formative period, between the searching 'sixties and, hopefully, the successful 'seventies, when computerized information resources for decision-making are expected to reach fulfillment. The introductory essay by Baughman and Brady offers an experienced challenge. John F. Chaney's paper on the organization of administrative systems provides still-valid advice of value to both executive and professional personnel struggling to make higher education MIS work. The Drews' projection of the future of the Higher Education General Information Survey and Lawrence's description of the WICHE-MIS program (now NCHEMS) are already of historical interest. The Wallhaus paper on modeling states principles and limitations that remain valid, and especially important for the RRPM audience. The "micromodels" described in the papers by Arcuri, Mason, and Meredith; Cahow, McDonald, and Wilkins;

and Jensens, Levin, Pendleton, and Uhl in the final chapters suggest important future operational models that may be expected to become major subsystems of future macro-models, as they become workable instruments of institutional management and planning systems.

T. R. Mason, University of Colorado

Journal of Socio-Economic Planning Sciences. Vol. II, Nos. 2, 3, 4, April 1969.

In November, 1967, the National Center for Educational Statistics, U. S. Office of Education, sponsored a Symposium on Operations Analysis of Education which was attended by 1100 educators, operations analysts, economists, and other social scientists. The Proceedings of that Symposium are published in this 500 page triple-issue of the Journal of Socio-Economic Planning Sciences. The contents range widely from general discussions of the "promise and pitfalls" of operations analysis in education to a presentation of specific models of various aspects of the educational system. Similarly, the educational spectrum from local primary-secondary schools through universities and national educational planning is covered. Most of the articles are disappointing if one is looking for a demonstration of accomplished achievements in the application of operations analysis in education as of 1967 -- particularly at the institutional level. However, articles by Bowman, Judy, Koenig and Keeney on university models pointed the way to the development of CAMPUS and RRPM. On the whole, the Proceedings give a reasonable view of the state-of-the-art and application of operations analysis in education as of 1967 -- a picture which probably has not changed dramatically in the succeeding four years.

P. J. Czajkowski, Univeristy of Illinois

Judy, Richard W. "Systems Analysis for Efficient Resource Allocation in Higher Education: A Report on the Development and Implementation of CAMPUS Techniques" in Management Information Systems; Their Development and Use in the Administration of Higher Education, J. Minter and B. Lawrence. Boulder, Colo.: WICHE, 1969, p. 41-58.

Levine, Jack B. "The Implementation of CAMPUS Simulation Models for University Planning", ibid. p. 59-68.

It is difficult to present a fair appraisal of this exceedingly important development in a short space. Nor is an appraisal of the extensive literature on CAMPUS the same as a review of experiences in running the programs. Familiarity with the CAMPUS concepts and structure is certainly a must for all serious RRPM users, because it is the same kind of a model. With some care the same data base can drive both models and CAMPUS V would have the added feature of comparing requirements against inventory and augmenting according to stated policies. However, CAMPUS V (in the public domain) suffers from uneven programming quality and from a number of concepts and procedures evidently routed in the Canadian academic tradition which are difficult to translate to the USA actuality. It has been run (at least partially) in the USA by Business School, University of Minnesota, University of Illinois, State University of New York at Stony Brook.

D. L. Trautman, S.U.N.Y. at Stony Brook

In Judy's article, the CAMPUS (Comprehensive Analytic Model for Planning in University Systems) methodology and computer model are described from the original pilot study (CAMPUS I) through the CAMPUS IV model. Included in the study is the special health sciences implementation which took place at the University of Toronto.

The input necessary to run the CAMPUS model is defined and illustrated. The model output reports were shown with examples and problems that can be analyzed using the CAMPUS model. The article contains thirty-one references to related materials.

Levine's paper describes the technological and sociological factors that must be considered when implementing a university planning model. The section on sociological factors is illustrated by the use of a cast of stereotype characters for top administrators, middle administrators, prefessional staff and analysts. The paper goes on to give guidelines for minimizing the implementation problems. Organizational structures are suggested and information flows are proposed.

G. Andrews, University of Colorado

Keller, John E. "Higher Education Objectives: Measures of Performance and Effectiveness" in B. Lawrence and J. Minter, op. cit., p. 79-84.

This theoretical paper attempts to produce an analytic comparison system for measuring instructional efficiency. It outlines the various types of institutional objectives according to the perceived role of the institution. Various indicants of effectiveness, output, educational benefits, efficiency, and the notion of value added are discussed. Finally, an analytic comparison system for measuring instructional efficiency if proposed which allows each institution to determine its own ranking of various measures of objective achievement according to its unique goals. This system would group together institutions with similar goals and objectives who could then compare their relative success within a peer group in terms of outputs and their costs. It is a good first attempt to systematize what has been found to be a most difficult problem and should be considered an introductory treatment for those in higher education or those related to it through the allocation determination process.

A. Harris, University of California
at Los Angeles

Kershaw, Joseph A. "Long-Range Planning at Williams." Williamstown, Mass.: Williams Alumni Review, May 1968.

This article is perhaps representative of several which describe computer models developed on individual campuses to address problems of overall college management. It should be of interest to the RRPM user by way of indicating that many vital questions can be illuminated without a huge data base or large sophisticated model. Williams modeled the interplay among tuitions endowment income, faculty and class size, enrollment, facilities, etc. on a campus-wide basis. Attention was focused on the last four years of the coming decade, and large deviations from feasibility were dealt with by changing the planning assumptions and rerunning the model. Mr. Kershaw felt that use of the computer model provided valuable insights on the relative influence of certain parameters and variables, and a guide as to what management decisions should be taken.

D. L. Trautman, S.U.N.Y. at Stony Brook

Koenig, Herman E. A Systems Model for Management, Planning and Resource Allocation in Institutions of Higher Education. East Lansing, Michigan: Dept. of Electrical Engineering and System Science, Michigan State University, April 1969.

Supported by a grant from the NSF, Koenig was among the early USA developers of a comprehensive model of the university system. Especially attractive features are its thorough analytical formulation in state space variable (with analysis of dynamics), its treatment of graduate students as both faculty and students, and the inclusion of the effect of stipends on the attraction and retention of graduate students. Technically the programming command language is flexible and responsive to user needs. It is an excellent model to learn on, to extend and adapt, or because of its extensive documentation, to supplement one's thinking about models in general. Operationally it is not a direct substitute for RRPM, but conceptually it is very useful background.

D. L. Trautman, S.U.N.Y. at Stony Brook

Kornfeld, Leo. "Managing Information: Three University Case Studies Show Varying Levels of Sophistication with All Systems GO for MIS" in College and University Business, March 1971, pp. 33-41.

Interesting description of how three universities have established integrated and coherent Management Information Systems. A good analysis of how a university MIS worthy of the name differs from a collection of unrelated and separate information subsystems.

R. J. Low, Portland State University

Mason, T. "The Road from Data to Decision-Making," Paper presented at the 15th Annual College and University Machine Records Conference, 1971.

This is a good discussion of the role of information systems in Planning and Institutional Research. The concepts and problems of file integration (vertical and horizontal) are discussed in considerable detail.

K. M. Hussain, New Mexico State University

Minter, John, and Lawrence, Ben, eds. "Management Information Systems: Their Development and Use in the Administration of Higher Education." Boulder, Colo.: WICHE, October 1969.

This document contains papers from the seminar on Management Information Systems held in April 1969, under the joint sponsorship of WICHE and the American Council on Education. It should be read by systems and data base designers for valuable insight into the type of information requirements which any comprehensive system will be expected to meet in the higher education environment. The papers by Gwynn and Chaney deal specifically with data base design considerations. An extensive bibliography is included.

M. Roberts, Stanford University

OASIS System Description, Project INFO, Palo Alto, Calif.: Stanford University.

OASIS (Online Administrative Information Systems) is an integrated computer system for university administrative needs developed at Stanford University under the auspices of Project INFO. The OASIS system is a "data base approach" to support the needs of many offices within the university. The same data base may also be used by management for budgeting, planning, resource allocation, and modeling.

OASIS is basically a software tool to support operational data collection, maintenance, and reporting. It is important to recognize that proper utilization of this tool is imperative if information from operational data files is to be usable for management purposes. In this regard the appropriate coding structures and file linkages must be coordinated between the administrative users of the system.

Most management systems and analytical tools, such as the NCHEMS Resource Requirements Prediction Model, would relate to Project INFO in two ways: (1) periodic "snapshots" of operational data files would be stored for later use in management reports or analytical tools, (2) historical, external or summary data sets required for managment analysis can be constructed and maintained with the facilities of OASIS. The induced course load matrix required by RRPM is an example of the latter.

The OASIS system provides an online data base management capability that may be used to serve the daily operational needs of an institution in such a fashion that management information needs can be largely by-products of daily operations. Appropriate utilization of this system requires a good deal of administrative planning and coordination of the system users.

C. R. Thomas, CAUSE

O'Neill, June. Resource Use in Higher Education. Washington, D.C.: Carnegie Commission on Higher Education, 1971, 106 p.

Dr. O'Neill examines the student credit hour outputs of American higher education from 1930 to 1967 and the use of institutional resources throughout this period. Basically, she finds that there have been virtually no productive gains in higher education since 1930.

G. B. Weathersby, University of California
at Berkeley

Peat, Marwick, Mitchell & Co. "Computer-Assisted Planning for Small Colleges" in Project Report - Phase I. New York: Peat, Marwick, Livingston & Co., May 1969.

Sutterfield, William D. "Managing Information: College Planning Could Use HELP," College and University Business, L, March 1971, 42-6.

The models SEARCH (by Peat, Marwick & Mitchell) and HELP (by Midwest Research Institute) have a lot in common having been heavily influenced by the same person, Dr. W. D. Sutterfield, now of Huron College (S.D.). Although they should be reviewed separately, these brief words should serve to interest the reader in further study. From their initial stages, supported by grants in the public domain, they each have been further developed (and sold) by private concerns. These are terminal operated models which treat planning variables aggregated to the campus level (in general) and appear to be admirable suited to the small, private college. Future inputs and constraints as well as all pertinent algorithms can be readily and flexibly inputted and a plotter can be connected to the output. Study of SEARCH and HELP is recommended for ideas on providing an aggregated, experimental mode of operation for RRPM. Furthermore, actual use will provide a keen satisfaction in the power of a simple programming language oriented to higher education (HELP'S PLANTRAN).

D. L. Trautman, S.U.N.Y. at Stony Brook

Steiner, George A. Top Management Planning. New York: The MacMillian Company, 1969, 795 p.

This is a well-organized reference to the field of business planning. In presenting the author's own philosophies, concepts, and approaches he presents a comprehensive survey of the field. This single volume contains a wealth of ideas that creative planners could apply in educational institutions. The depth of thinking described in Steiner's book and applied successfully in business are reflected only in a limited way in the literature of higher education. Two chapters are particularly valuable to RRPM project managers: a chapter on the systems approach to decision-making, which places computer tools in a broader decision-making context; and the concluding observations which include discussion of pitfalls, the nature of planning, the behavior of people, and the process and its results. Includes an extensive bibliography on business planning.

B. Cohn, University of Utah

Sutterfield, William D. "Managing Information: College Planning Could Use HELP," College and University Business, L, March 1971, 42-6.

A clear explanation of a long-range planning model developed by Midwest Research Institute of Kansas City for a group of midwestern colleges. The Institute would, no doubt, be glad (for a fee) to install HELP and get it operating in your institution. Although it seems like a sound model, there is no evidence from the article that it uses the common data elements and discipline/division categories that RRPM employs. The model appears much less sophisticated than RRPM.

R. J. Low, Portland State University

Thomas, C. R. Data Element Dictionary (1st Ed.). Boulder, Colo.: WICHE, 1970.

Technical Reports 7-9, 11-12 on Students, Staff, Facilities, Course and Finance, respectively. An early attempt at defining data elements in higher education was in the "Henle Report" (reviewed by Dr. Trautman). The Data Element Dictionary is another attempt sponsored by NCHEMS at WICHE. It is compatible with all projects at NCHEMS including the RRPM. It may well be the basis to information exchange between institutions of higher education.

The first edition lists data elements describing each one briefly with examples and an indication as to the different NCHEMS models in which the data elements may be used. The second edition will suggest code structures and detailed category definitions.

K. M. Hussain, New Mexico State University

Thompson, Robert K. Higher Education Administration: An Operating System Utilizing A Dynamic Simulation Model. Seattle, Wash.: Office of the Vice President for Planning and Budgeting, 1970. (Based on a master's thesis, dated 1969.)

The attractiveness of this model, which like RRPM links enrollments, faculty and space, lies in its foundation on pertinent time delays and its decision rule of basing enrollments on adequate faculty or space. The planning horizon is fifty years. Programming is in DYNAMO to go with the problem formulation in the language of industrial dynamics. This report is a must for the RRPM user wanting to broaden his understanding of university models or to extend the capabilities of RRPM. Time delay data on building construction, obsolescence and on faculty hiring and retention may not be readily available but appear to be pertinent to a complete model.

D. L. Trautman, S.U.N.Y. at Stony Brook

Weathersby, George B. and Weinstein, Milton C. A Structural Comparison of Analytical Models for University Planning, Paper P-12. Berkeley, Calif.: Office of Analytical Studies, University of California, August 1970.

This report represents an interesting comprehensive scholarly comparison of the major models for resource allocation developed through Summer 1970. Viewpoints apparently are based on the available summary literature. Persons having operational experience with one or more of the models may report differently, but the report as a whole is a must for anyone seriously interested in university modeling. The valuable descriptions and comparisons of thirty models are aided significantly by structuring according to function, theory, methods, subjects, data uses and status. The models are grouped for (a) comprehensive university simulation, (b) university performance optimization, (c) special purpose university planning, and (d) national educational planning. Tables enable the reader quickly to spot the characteristics of any model, and in particular, the relation of RRPM to the others.

Of equal interest to the model user wanting to extend RRPM is the concluding chapter highlighting "gaps in the range of existing applications of decision making technology to higher education."

D. L. Trautman, S.U.N.Y. at Stony Brook

REFERENCES

CHAPTER ONE

1. A Resource Requirements Prediction Model (RRPM-1)--An Introduction to the Model, NCHEMS Technical Report No. 19 (Boulder, Colo.: NCHEMS. 1971).

2. A Resource Requirements Prediction Model (RRPM-1)--Programmer's Manual, NCHEMS Technical Report No. 22 (Boulder, Colo.: NCHEMS. 1971).

3. A Resource Requirements Prediction Model (RRPM-1)--Input Specifications, NCHEMS Technical Report No. 23 (Boulder, Colo.: NCHEMS. 1971).

4. A Resource Requirements Prediction Model (RRPM-1)--Report on the Pilot Studies, NCHEMS Technical Report No. 21 (Boulder, Colo.: NCHEMS. 1971).

5. For a thorough discussion on models, see J. W. Forrester, Industrial Dynamics (Cambridge, Mass.: The M.I.T. Press, 1961), pp. 49-59. For a discussion on modeling, see R. A. Wallhaus, "Modeling as a Tool in Management Information Systems" in C. B. Johnson and W. G. Katzenmeyer, Management Information Systems in Higher Education: The State of the Art (Durham, N. C.: Duke University Press, 1969), pp. 125-44. For another good discussion, see S. E. Elmaghraby, "The Role of Modeling in IE Design," The Journal of Industrial Engineering, XIX (June 1968), 292-305. The name of the article and its location should not discourage the educational practioner.

6. For an excellent discussion of project management, see D. I. Cleland and W. R. King, Systems Analysis & Project Management (N.Y.: McGraw-Hill Book Company, Inc., 1968).

CHAPTER TWO

1. For a discussion of network diagrams in education, see D. L. Cook, PERT--Applications in Education (Washington, D.C.: U.S. Department of Health, Education and Welfare, 1966), OE-12024; and H. W. Handy and K. M. Hussain, Network Analysis for Educational Management (Englewood Cliffs, N.J.: Prentice-Hall, Inc. 1969).

2. The consistency of the basic model RRPM-1 has been tested successfully by eight pilot institutions. What needs to be validated is the effect of modifications using institutional data.

CHAPTER THREE

1. For an attempt to reduce core requirements for RRPM-1.3, see the detailed report by Humboldt State College available at NCHEMS. Boulder, Colo.

2. These were 14 disciplines or departments, 11 majors, 3 student levels, 3 course levels, 3 instructional types, 5 faculty ranks and 22 space types.

3. Humboldt State College, New Mexico Junior College, and Portland State.

4. New Mexico Junior College.

5. U. C. L. A. and S. U. N. Y. at Stony Brook.

6. For a discussion of the "analytical team," see A Resource Requirements Prediction Model (RRPM-1): An Introduction to the Model, NCHEMS Technical Report No. 19 (Boulder, Colo.: NCHEMS. 1971), Section 7.

CHAPTER FOUR

1. See Program Classification Structure (1st ed.) to be published by NCHEMS at WICHE, Boulder, Colo., in Fall 1971.

2. NCHEMS Technical Report No. 22, op. cit.

3. This level is institutionally defined and can be used to simulate resources required at any level of instruction; e.g., discipline, department, school, or college.

4. William T. Morris, "On the Art of Modeling," Management Science, XIII (August 1967), B707-B717.

5. For a critique of computerized statistical packages, see J. W. Longley, "An Appraisal of Least Squares Programs for the Electronic Computer from the Point of View of the User," American Statistical Association Journal, LXII (September 1967), 819-41.

6. For a discussion of this subject, see the Manual to the Analytical Module, available, but not supported, at NCHEMS, Boulder, Colo.

7. NCHEMS Technical Report No. 21, op. cit., Table No. 4.

CHAPTER FIVE

1. Data Element Dictionary, (First ed.) NCHEMS, (Boulder, Colo.: 1970). These are being continually updated and are for different files: Student, Staff, Facilities, Course and Finance.

2. See Higher Education Facilities Planning and Management Manuals, NCHEMS Technical Report No. 14-1 through 14-7, (Boulder, Colo.: NCHEMS 1971).

3. Student levels and instruction levels are ignored here in order to reduce detail. It should be noted that the number of academic departments does not equal the number of majors. This is intentional and emphasizes the fact that a department may have none, one or several majors and that a major may cut across several departments, "belonging" to none of them (as in the illustration). Also a department may offer courses in one discipline or more than one discipline.

4. This section is, perhaps, an optimistic interpretation of the literature concerning the ICLM. The reader may consult the following sources: David Breneman, *The Stability of Faculty Input Coefficients in Linear Workload Models of the University of California* (Berkeley: University of California Office of Planning and Analysis, 1969); Frank Jewett, Alan Feddersen, Ronald Lawson, and William O'Grady, *The Feasibility of Analytic Models for Academic Planning: A Preliminary Analysis of Seven Quarters of Observations on the Induced Course Load Matrix*, (Los Angeles: California State Colleges, 1970); and Ronald Lawson and Roger Emanuel, *Student Credit Coefficient Matrices: Stable for University Planning?* (Berkeley: University of California, 1970); and Enscore E. E. *et. al.*, *Development of a Model for the Prediction of Instructional Activities* (University Park: Pennsylvania State University, Office of Vice President for Planning, 1970).

5. This last mentioned cause deserves emphasis. It is generally agreed that majors reporting is poor. There is less agreement as to how the process may be improved.

6. It is interesting to note, however, if one believed the faculty forecasts generated by RRPM and hired accordingly, it would be observed after the fact that the RPPM forecasts had been exactly "correct."

7. An independent variable is one that is determined externally and independently of the model as distinct from a dependent variable that is determined within the model.

8. For a review of existing models relating to Student Flow, see C. C. Lovell, *Student Flow Models: A Review and Conceptualization*, NCHEMS Technical Report No. 25, (Boulder, Colo.: NCHEMS, 1971), pp. 5-16.

9. The Student Flow Model currently being developed by NCHEMS will be pilot tested and publicly released around Fall 1972.

10. See NCHEMS Technical Report No. 21, *op. cit.*, Table No. 4

11. These variables are average section size, distribution of FTE faculty by rank, salaries (faculty & administrative), ratio of weekly student contact hours to student credit hours, average faculty load, space factors, space increments, and space inventory.

CHAPTER SIX

1. See T. H. Naylor, *et. al.*, *Computer Simulation Techniques* (N.Y.: John Wiley and Sons, Inc., 1966), pp. 311-14. The authors discuss Synthetic Apriorism, Ultreaempericism, Positive Economics and Multistate Verification. For a discussion of historical verification see pp. 316-17.

CHAPTER SEVEN

1. Technical Report No. 19, op. cit., Appendix A

2. Ibid., Appendix B

3. For another diagrammatic representation of the planning process, see B. Cohn's summary report on the pilot study at the University of Utah, NCHEMS Technical Report No. 21, op. cit., Attachment 7.

4. For further discussion about planning and performance evaluation, refer to the bibliography of this report under Keller.

5. See R. Low's unpublished report of RRPM implementation at Portland State, available at NCHEMS, Boulder, Colo.

CHAPTER EIGHT

1. P. E. Rosove, Developing a Computer-Based Information System (N. Y.: John Wiley & Sons, Inc., 1967), p. 294.

2. For a good discussion of this subject, see A. Zander, "Resistance to Change--Its Analysis and Prevention" Advanced Management (June, 1950), pp. 9-11.

3. J. Caffrey, "The Human Side MIS Implementation" in Focus on MIS: A Report on the WICHE-ACE Higher Education Management Information Systems Seminar (Boulder, Colo.: Western Interstate Commission for Higher Education, 1969), pp. 11-12.

4. For a good discussion of this topic, see J. Farmer, An Approach to Planning and Management Systems Implementation (L.A.: California State Colleges, 1971), available at NCHEMS at WICHE, Boulder, Colo. It discusses RRPM within the context of an MIS for higher education. See also C. W. Churchman, "Systems Planning for Implementation of Change" The Computer in American Education, eds. D. D. Bushnell and D. W. Allen, (N.Y.: John Wiley & Sons, Inc., 1967) pp. 44-48.

5. See E. G. Bogue, "An Inquiry into the Relationship Between Instructional Cost Patterns and Assumptions Influencing Analysis of Basic Data in Unit Cost Studies" (paper presented at the 1971 AIR Forum, Denver, Colo., 1971.) For a critique of this article, see the annotated bibliography.

6. Detailed Report on RRPM Implementation by Humboldt State College, p. 15. On file at NCHEMS at Boulder, Colo.

7. For a thorough discussion see P. W. Greenlaw, et. al., Business Simulation in Industrial and University Education (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1962).

8. One of the earliest and most used is an IBM game. See D. E. Shuford and W. W. Klaprath, The University Administration Decision Laboratory Game (International Business Machines Corp., 1965). Other games include MICRO-UI and CEM designed and used in training seminars by NCHEMS, Boulder, Colo.

9. See the report of New Mexico Junior College, Chap. IX, Attachments A, B, & C.

10. To one interested in starting a library on RRPM-related literature, see the bibliography in J. Minter and B. Lawrence (eds.), Management Information Systems: Their Development and Use in the Administration of Higher Education (Boulder, Colo.: Western Interstate Commission for Higher Education, October 1969), pp. 101-14. See also the annotated bibliography in this document.

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